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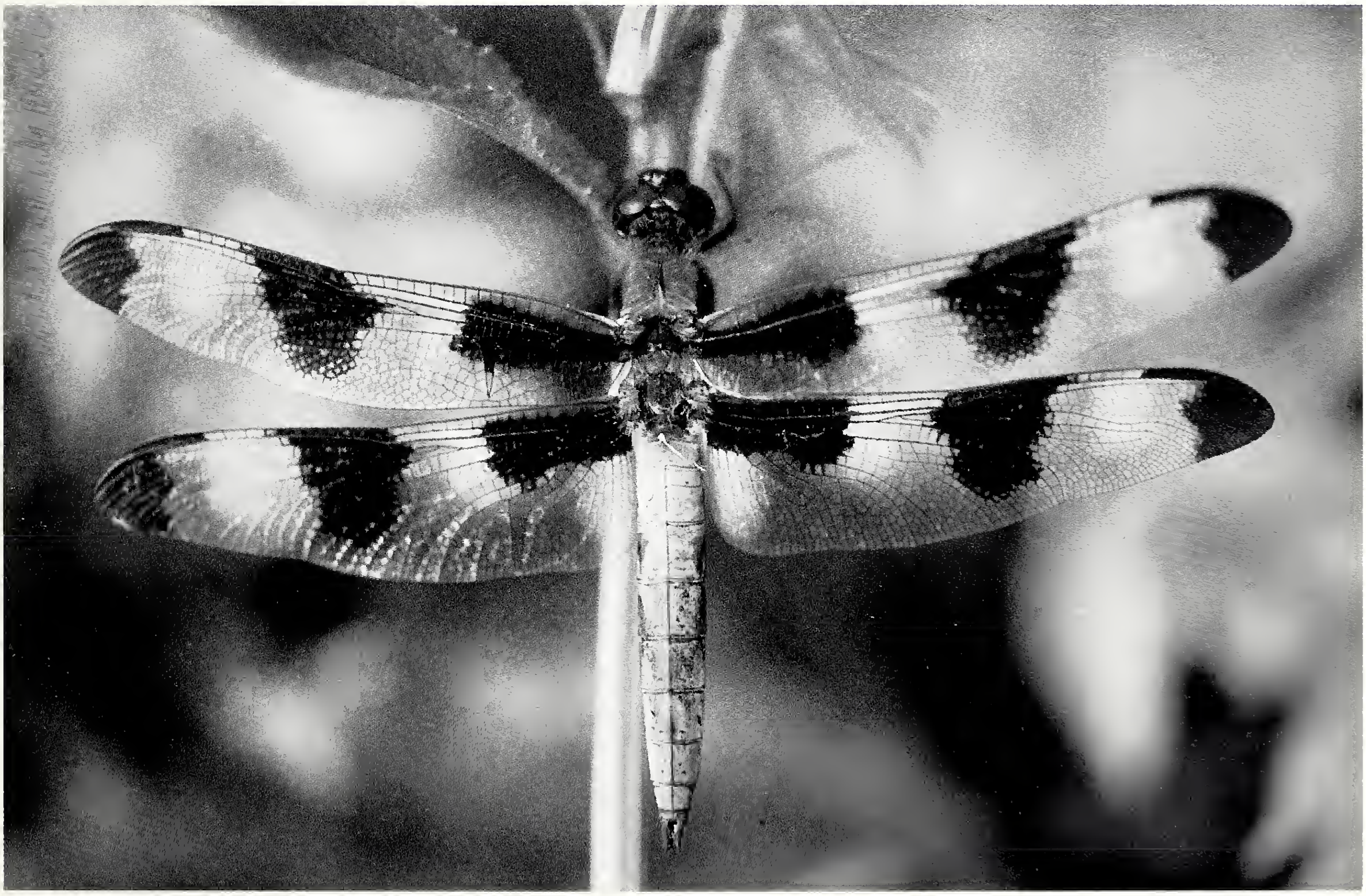

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Cover photo: Photo of a male dragonfly, the Twelve-Spotted Skimmer, *Libellula pulchella* Drury from Tippecanoe State Park. This large skimmer is common around still water throughout Indiana, from late May to early October. The common name derives from the dark spots on the wings. This photo is from the book, *Dragonflies of Indiana*, by Dr. James Curry of Franklin College.

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CORRELATION BETWEEN COMPRESSION OF THE PROXIMAL TIBIA AND GROSS EXTERNAL INDICATORS OF JOINT DEGENERATION

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ABSTRACT. Previous research conducted on the dynamics of trabecular bone suggests that changes in the dimensions of the proximal metaphysis of the tibia would be consistent with joint degeneration of a mechanical etiology. Data on the circumference of the proximal metaphysis were collected from 44 tibiae exhibiting various degrees of degeneration of the proximal surfaces. Statistical analysis indicates that the broadness of the proximal metaphysis is positively correlated with the degree of observable joint degeneration as scored by Jurmain's (1975) method. Circumference to length ratios in the metaphysis are higher in specimens with a greater degree of observable joint degeneration, and correlation between bone length and circumference is less.

Keywords: Mechanical joint degeneration, osteoarthrosis, tibia, trabecular bone

Recent anthropological studies of activity patterns in human skeletal populations have generally focused on either cortical bone dynamics (e.g., Ruff 1987; Ruff & Hayes 1983) or joint degeneration (e.g., Bassett 1982; Bridges 1989, 1991, 1994; Jurmain 1977, 1980, 1990; Ortner 1968). While research on the dynamics of cortical bone is increasing in sophistication, little emphasis has been placed on refining the study of joint degeneration in skeletal populations. This imbalance may be due in part to an ignorance of and disinterest in trabecular bone dynamics among physical anthropologists. Experimental and clinical evidence (e.g., Radin & Rose 1986; Radin et al. 1973) suggests that trabecular bone in the metaphyses plays an integral role in the initiation and progression of joint degeneration of a mechanical etiology.

The role that trabecular bone plays in the initiation and progression of joint degeneration suggests that mechanical stresses can cause observable and quantifiable internal and external remodeling of joints prior to significant or total cartilage loss and the subsequent appearance of more conspicuous bony changes. The term "joint degeneration" is used here to refer to a suite of bony changes observable in joints as the result of mechanical stress and/or other conditions. It is not meant to refer exclusively to osteoarthrosis, osteoarthritis, or any other specifically defined medical condition, diagnosis of the severity of which requires the presence of soft tissue.

Gross changes of the joint surface, such as pitting, eburnation, and marginal lipping, are commonly used to identify and characterize joint degeneration in skeletal populations. These changes occur subsequent to significant or total deterioration of the articular cartilage (Ortner & Putschar 1985). In archaeological studies, the degree of joint degeneration is often scored using an ordinal scale. Such studies have generally interpreted observed differences in the distribution of degenerative joint disease as the result of particular activities: the use of tumplines (Bridges 1994), atlatls (Angel 1966), and grinding stones (Miller 1985), for example, have been suggested as "causes" of joint degeneration. These studies often cite "general wear-and-tear" (e.g., Bridges 1991; Jurmain 1977, 1990) as the primary cause of joint degeneration, and fail to discuss the specifics of activity-related joint stress that might be of use in more clearly defining the behavioral implications of joint degeneration (see Miller 1985 for an exception).

Some of the shortcomings of the current approach to joint degeneration in skeletal populations can be addressed by recognizing "non-pathological" changes in the proximal tibia that are related to joint degeneration of a mechanical etiology. Specifically, the basic dimensions of the proximal tibia are examined in relation to Jurmain's (1975) method of scoring the degree of joint degeneration in skeletal remains.

MECHANICAL STRESS AND JOINT DEGENERATION

All bone is generally classified as either cortical bone or trabecular bone. The two kinds of bone are differentiated on the basis of their porosity: cortical (compact) bone porosity varies from 5–30%; trabecular (spongy) bone porosity varies from 30% to over 90% (Carter & Hayes 1977). Cortical bone is the dense bone that forms the outer shell of most bones and makes up the diaphyses of long bones. Trabecular bone is a "three-dimensional lattice composed of plates and columns" (Carter & Hayes 1977) that is found in the medullary cavity of most bones. In the long bones, trabecular bone is concentrated in the metaphyses and epiphyses.

The distribution of cortical and trabecular bone in the long bones is determined by biomechanical stresses, and contributes to the overall strength of the bone. Trabeculae are generally oriented along lines of stress (i.e., Wolff's Law). While the formation and mechanics of trabecular architecture are complex (e.g., Carter et al. 1989; Fyhrie & Carter 1986; Heřt 1994), it is widely agreed that metaphyseal trabecular bone is most sensitive to forces transmitted in the direction of the long axis of the bone (axial forces). Interestingly, Ruff & Hayes (1983) note that resistance to axial loading (compression) is the least critical determinant of diaphyseal shape in lower limb bones. The shape of long bone diaphyses is influenced by bending (shear) and torsional loads (Ruff 1987), and the thickness of diaphyseal cortex in the axial plane forms a structure that is virtually impervious to fracture by a compressive load under normal circumstances (Cowin 1995). As trabecular structures are much more elastic than the denser cortical bone, the concentration of trabecular bone in a long bone metaphysis functions as a "bumper" to absorb forces transmitted across the joint.

Because the elasticity of trabecular bone plays an integral role in joint mechanics, changes in the elasticity of trabecular bone are of consequence to the normal functioning of a synovial joint. Many studies have suggested that the compressive strength and elasticity of trabecular bone is related to its density (e.g., Bartley et al. 1966; Bell et al. 1967; Carter & Hayes 1977; Weaver & Chalmers 1966). If trabecular bone becomes too dense (too strong in the axial plane), it becomes inelastic and cannot function as a shock absorber. If trabecular bone is not dense enough (too weak in the axial plane), it cannot absorb normal forces and is in danger of fracture (hence the occasionally mentioned mutual exclusion of osteoarthrosis and osteoporosis [e.g., Burr et al. 1983]). Research conducted since the 1960s has investigated a number of other relationships between the density, contiguity, strength, organization, and number of trabeculae (e.g., Carter & Hayes 1977; Carter et al. 1989; Goulet et al. 1994; Parfitt et al. 1983; Pugh et al. 1973a, b; Pugh et al. 1974; Radin & Rose 1986; Radin et al. 1973).

Radin & Rose (1986) and Radin et al. (1973) suggest that the initiation and progression of mechanical joint degeneration (osteoarthrosis) is intimately related to the dynamics of metaphyseal trabecular bone. There is evidence that the deterioration of articular cartilage is preceded, and even caused, by changes in the subchondral bone and trabeculae which underlie it. Using live rabbits, Radin et al. (1973) demonstrated that repeated axial loading of knee joints produced fractures of individual trabeculae. These fractures subsequently healed, with a resulting increased stiffness of the subchondral bone. By studying the timing of changes in both cartilage and subchondral bone, Radin et al. (1973) showed that stiffening of the subchondral bone preceded degenerative changes in the articular cartilage. The compressive strength of normal trabecular bone is related to its density: the more bone present per unit of volume, the stiffer the bone. As the trabeculae fracture and heal, bone is added and the trabecular structure loses elasticity (Radin & Rose 1986). Thus the loss of elasticity brought about by the stiffening of the subchondral bone can cause the cartilage to degenerate as it is exposed to forces normally absorbed by the underlying trabecular bone.

Additional studies have supported the contention that trabecular micro-fracturing and healing can cause an increase in the stiffness of subchondral bone and lead to the deterioration of articular cartilage. Pugh et al. (1974) found a significant difference in the contiguity (interconnectedness) and relative stiffness of trabecular bone underlying "normal" and "abnormal" (deteriorating) cartilage. Guo et al. (1994) suggest that the strength of trabecular bone "may be highly sensitive to fractures of individual trabeculae" (see also Goulet et al. 1994). The disorganization and thickening of subchondral trabeculae subsequent to compressive fracture is well-documented (Pugh et al. 1974; Pugh et al. 1973b; Radin et al. 1973). This thickening is plainly visible in radiographs as relatively discrete areas of increased density in arthrotic knees (e.g., see Maquet 1976, 1985). Thus, the relationship between the density and axial compression strength of trabecular bone (Bartley et al. 1966; Bell et al. 1967; Carter & Hayes 1977; Goulet et al. 1994; Weaver & Chalmers 1966) is probably a combined function of the thickness of individual trabeculae, the number of trabeculae, and the organization of a trabecular structure.

Taken together, available evidence strongly suggests that an increase in the density of subchondral trabecular bone is a key factor in joint degeneration of a mechanical etiology. This view of joint degeneration raises specific expectations concerning changes in the internal and external architecture of the joint in relation to mechanical stress. Axial "compression" of the proximal tibia would be consistent with the progression of mechanical joint degeneration as described above. Repeated fracturing and healing of subchondral trabeculae and trabeculae deeper into the metaphysis could result in a "compression" of the metaphyseal shell in the axial plane. There is presently no direct evidence for trabecular fractures occurring deep into the metaphysis. There is good evidence to suggest that axial forces are transmitted to this depth, however, and that these forces result in increased density and stiffness of trabecular bone through some mechanism. Finlay et al. (1989) studied the stiffness of trabecular bone underlying healthy and osteoarthrotic plateaus, and suggested that the trabecular bone below the plateaus of arthrotic tibiae showed an increased stiffness at unspecified depths (less than 30 mm). Areas of increased trabecular density below affected plateaus are visible in radiographs of living subjects (Maquet 1976), and plainly extend beyond the subchondral bone. Goldstein et al. (1983) observed patterns of increased stiffness in trabecular bone at a depth of 40–50 mm below the plateaus.

In vivo, the metaphyseal cortical shell is flexible. In a study of fresh femora from autopsy specimens, for example, Hirsch & Frankel (1961) noted that "strains in various parts of the cortical shell could be seen" as forces were applied. As both cortical and trabecular bone are viscoelastic and exhibit a variety of attributes which allow them to deform and "flow" (Bowman et al. 1994), it is reasonable to suspect that the shape of the cortical metaphyseal shell of the proximal tibia may vary in conjunction with the state of the underlying trabecular structure and the shape of the articular surfaces. If the cortical shell of the proximal tibia tends to be compressed in conjunction with mechanical joint degeneration, the circumference of the tibia immediately inferior to the plateau would be expected to be greater relative to bone length in specimens exhibiting grossly observable signs of joint degeneration.

METHODS

Measurement and observational data were collected from 44 tibiae from the University of Chicago collection housed at Southern Illinois University at Carbondale, Illinois. Although information concerning the origin of the collection is imprecise, it is generally thought to be composed of cadavers collected by the University of Chicago dissecting laboratories in the first half of the 20th century (White 1999). As it is a medical sample, it is in fair condition, with joint surfaces, metaphyseal cortical shell, and trabeculae generally intact. The collection contains at least 180 tibiae, representing at least 92 adult individuals. The collection includes individuals that exhibit various degrees of gross degeneration of the joint surfaces, as well as a large number of individuals who display no such involvement.

The sample requirements for this study were quite basic. For the most part, the sample needed only to consist of relatively well-preserved tibiae. Although the sample did not need to represent a "population" in the usual sense, it had to contain specimens which displayed a suitable range of degenerative involvement. Most of the individuals in the collection lack pelves and crania, and sex could not be reliably estimated for most of the collection.

Table 1.—Jurmain's (1975) scale for scoring degeneration of the proximal tibia.

Location	Score	Morphology
Lateral condylar tubercle	0	Rounded
	1	Pointed (definite build-up)
	2	Obliterated by eburnation
Medial condylar tubercle	0	Rounded
	1	Pointed (definite build-up)
	2	Obliterated by eburnation
Insertion of posterior cruciate ligament	0	Smooth contour
	1	Some excavation with lipping; spicules (<50% intercondylar space)
	2	Deep excavation with significant pointed spicules (>50% of intercondylar space)
Lateral marginal lipping	0	None
	1	Moderate (>50% of circumference)
	2	Pronounced (vertical build-up)
Medial marginal lipping	0	None
	1	Moderated (>50% of circumference)
	2	Pronounced (extends horizontally)
Lateral articular surface	0	Smooth
	1	Small bony accretion(s)
	2	Pitted and/or eburnated
	3	Pitted and/or eburnated >25% of surface area
Medial articular surface	0	Smooth
	1	Small bony accretion(s)
	2	Pitted and/or eburnated
	3	Pitted and/or eburnated >25% of surface area
Facet for head of fibula	0	Smooth and flat
	1	Marginal lipping present >50% of circumference (or sharp anywhere)
	2	Projected (sharp); lipping >25% of circumference
	3	Fibula fused to tibia

The sample was chosen based both on condition (White 1999) and the degree of observable joint degeneration as scored using Jurmain's (1975) method. Jurmain's (1975) method uses an ordinal scale, scoring the morphology of eight locations on the proximal tibia (Table 1). The scores from all locations are added together to arrive at a final "degeneration score." A tibia with no external signs of joint degeneration would have a score of 0. The most severely affected tibia would have a score of 19. Tibiae chosen for this study have scores ranging from 0–13. It should be noted that some components of Jurmain's (1975) scale are not diagnostic of osteoarthrosis in a clinical or medical sense. In its use here, Jurmain's (1975) scale should be considered a general measure of the condition of the proximal tibia, reflecting a broad amalgam of gross bony degenerative changes rather than accurately characterizing the severity of a disease condition that can be effectively measured only when soft tissue is present.

To simply characterize the size of the metaphyseal cortical shell at equivalent points, a proportional scale was established on each specimen. The condyle-malleolus length (CML) of the tibia (the distance from the most distal point of the medial malleolus to the superior surface of the lateral plateau) was measured using an osteometric board (as in Bass 1987). Points were then established on the tibia by dividing the condyle-malleolus length by 20 and measuring the resulting distance down the shaft with an osteometric board, proceeding distally from the plateau (Fig. 1). Point A, for example, was located inferior to the lateral plateau at a distance of $\frac{1}{20}$ of the condyle-malleolus length. Subsequent points were likewise located, each point $\frac{1}{20}$ of the condyle-malleolus length from the previous proximal point. Circumference was determined at each

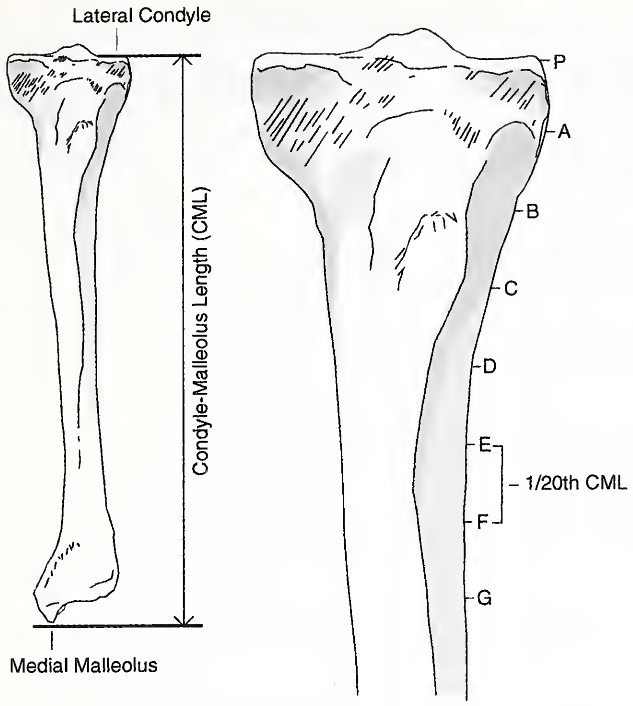

Figure 1.—Measurement of condyle-malleolus length of tibia (left) and establishment of points for measuring metaphyseal circumference (right).

of these points using a cloth tape. Measurements were taken from the plateau to point G. Point G was located distal to the portion of the metaphysis that contained significant amounts of trabecular bone, and was considered suitably distal to the plateau.

Among tibiae that exhibit no gross signs of joint degeneration (or where such signs are mild), a stronger relationship between bone length and circumferences is expected. Among tibiae that exhibit more pronounced gross signs of joint degeneration, a weaker relationship between bone length and circumference would be expected if the metaphysis has experienced disproportionate compression. Such expectations can be tested by calculating correlation coefficients between condyle-malleolus length and circumference measurements, examining differences in the ratio of circumference to condyle-malleolus length, and examining correlation between the degeneration score and the amount of metaphyseal compression proportionate to condyle-malleolus length.

RESULTS

In tibiae with a degeneration score of 0, 1, or 2 (n = 29), correlation between circumference and condyle-malleolus length is high at all measured points, with r_s ranging from 0.59 at A to 0.82 at F (Fig. 2). All of these correlations are statistically significant at the P = 0.05 level ($r_{s\text{crit}}$ = 0.37, t_{crit} = 2.052, df = 27). In tibiae with a degeneration score greater than 2 (n = 15), correlation between condyle-malleolus length and circumference is lower, ranging from 0.08–0.51 (Fig. 2). Correlations at P through G are not significant at the P = 0.05 level ($r_{s\text{crit}}$ = 0.52, t_{crit} = 2.160, df = 13). Spearman's rank-order statistic (r_s) was used rather than parametric correlation because the condyle-malleolus length measurements exhibit a non-normal distribution.

The relationship between circumference and condyle-malleolus length in the proximal fifth of the tibia is weaker in tibiae with a higher degeneration score. By dividing each of the circumference measurements by the condyle-malleolus length, it is possible to characterize the circumference of the proximal tibia in relation to bone length. Mean ratios of circumference to condyle-malleolus length at P through G are shown in Fig. 3. The mean ratio of circumference to condyle-malleolus length is consistently greater in tibiae with a degeneration score greater than 2, indicating that the proximal portions of tibiae in this group are, on average, broader in proportion to their total length. This difference is greatest at P through D. The t-test and Wilcoxon statistics return similar results about the statistical significance of these differences. Both agree that the ratio of circumference to condyle-malleolus length is significantly higher at the P = 0.05 level (t_{crit} = 2.018; z_{crit} = 1.96) at B, C, D, and E. The t-test also returns a significant result at P and A. The Wilcoxon statistic returns an additional significant result at F.

These probabilities are two-tailed. If the statistical results are corrected for the Bonferroni effect by dividing the critical alpha (0.05) by the number of tests (8), a probability of 0.006 would be required for statistical significance (t_{crit} = 2.895; z_{crit} = 2.748). At this level, statistical significance is limited to B, C, D, and E. There is justification for phrasing the statistical hypothesis directionally, as it is theoretically expected that "affected" specimens would exhibit greater circumference in proportion to length. If the hypothesis is phrased directionally, several more results are significant at the P = 0.006 level (t_{crit} = 2.626; z_{crit} = 2.512).

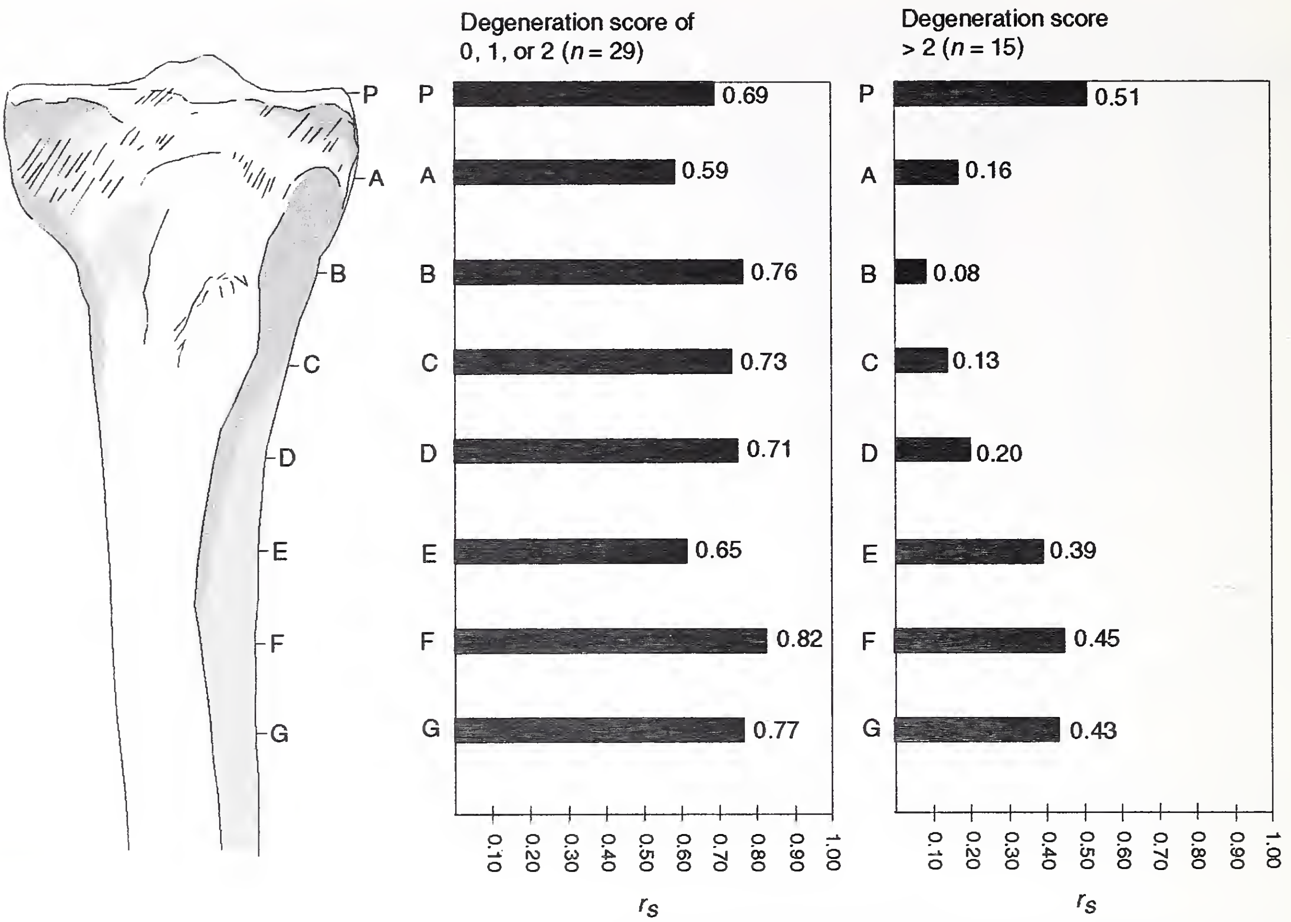

Figure 2.—Rank-order correlation (r_s) between condyle-malleolus length and circumference at points P through G in "unaffected" (degeneration score of 0, 1, or 2) and "affected" (degeneration score > 2) specimens. Degeneration score is calculated by combining the ordinal scores of eight locations on the proximal tibia using Jurmain's (1975) method (see Table 1).

Circumference data from each specimen can be combined into a single, size-adjusted measurement of metaphyseal circumference. This can be done by using the circumference measurement at G as a "standard" for each specimen. The circumference at G was chosen as a "standard" because is situated well into the diaphysis and shows little indication of involvement in metaphyseal broadening (i.e., circumference at G is relatively highly correlated with condyle-malleolus length in both "affected" and "unaffected" groups, and the ratio of circumference at G to condyle-malleolus length is not significantly different between these groups). By subtracting the circumference at G from the circumference at each of the other locations on the metaphysis superior to G (with the exception of the plateau), a relative measure of the broadness of the metaphysis (MB) is derived:

$$\text{MB} = (\text{CA-CG}) + (\text{CB-CG}) + (\text{CC-CG}) + (\text{CD-CG}) + (\text{CE-CG}) + (\text{CF-CG})$$

where CA is the circumference at A, CB is the circumference at B, etc.

A plot of this measurement against degeneration score is presented in Fig. 4. There is a positive correlation between the two variables. This correlation is significant at the $P = 0.001$ level using Spearman's rank-order statistic ($r_s = 0.57$, $t = 4.461$, df = 42), indicating that tibiae with higher degeneration scores tend to be broader in the proximal portions of the bone relative to bone size. Metaphyseal broadness is positively correlated with condyle-malleolus length to some degree ($r_s = 0.21$, $P = 0.176$, $t = 1.378$, df = 42) in the combined sample ($n = 44$). Degeneration score is also positively correlated with condyle-malleolus length ($r_s = 0.11$, $P = 0.474$, $t = 0.723$, df = 42). Neither of these correlations is statistically significant.

DISCUSSION AND CONCLUSIONS

The data presented here suggest that increases in the circumference of the metaphy-

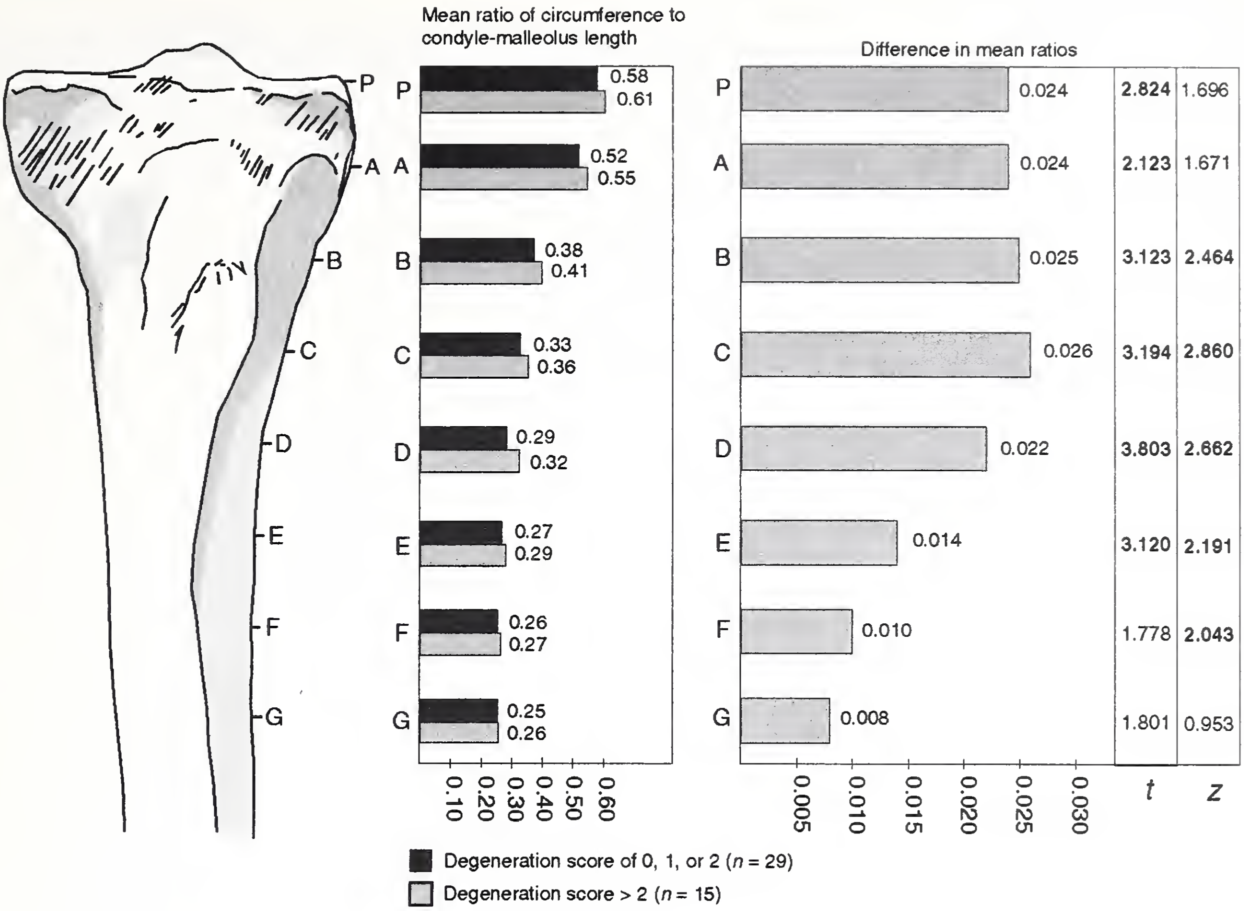

Figure 3.—Ratio of circumference to condyle-malleolus length at points P through G in "unaffected" (degeneration score of 0, 1, or 2) and "affected" (degeneration score > 2) specimens. The difference in mean ratios was evaluated using the Wilcoxon statistic (*z*) and the *t*-test (*t*). Results significant at the $P < 0.05$ level are in bold. Degeneration score is calculated by combining the ordinal scores of eight locations on the proximal tibia using Jurmain's (1975) method (see Table 1).

seal cortical shell of the proximal tibia are correlated with the grossly observable external indicators of joint degeneration commonly used by physical anthropologists. Difference in the mean ratio of circumference to condyle-malleolus length in "unaffected" (degeneration score of 0, 1, or 2) and "affected" (degeneration score > 2) specimens is greatest at points P through D. Correlation between condyle-malleolus length and circumference is at its lowest in "affected" specimens at A through D. The increase in the circumference at point P is accompanied by an antero-posterior broadening of the lateral plateau, a flattening of the medial plateau, and a decrease in the angle between the plateaus (White 1999). These findings are consistent with research that suggests that the trabeculae-filled metaphysis of the proximal tibia functions to absorb the forces transmitted across the knee joint, and that such forces may cause a compression of the metaphysis in the axial plane.

The mechanisms responsible for these changes in the circumference are undetermined. Looking only at the proximal portion of the tibia, the patterning of correlations suggests that the greatest changes in circumference occur within the proximal fifth of the shaft. In the present sample, this corresponds to a depth of approximately 61–87 mm below the plateaus. Patterned differences in the properties of trabecular bone (presumably associated with forces transmitted across the knee joint) have been recognized through the upper portions of this depth range. Goldstein et al. (1983) documented patterns of increased trabecular stiffness at a depth of 40–50 mm below the plateaus, and suggested that these patterns become more peripheral (i.e., oriented towards the outside of the shaft) as they progress distally, perhaps transmitting loads to the cortex. It is possible that trabecular fracturing and/or some other mechanism of restructuring are operating inferior to the sub-

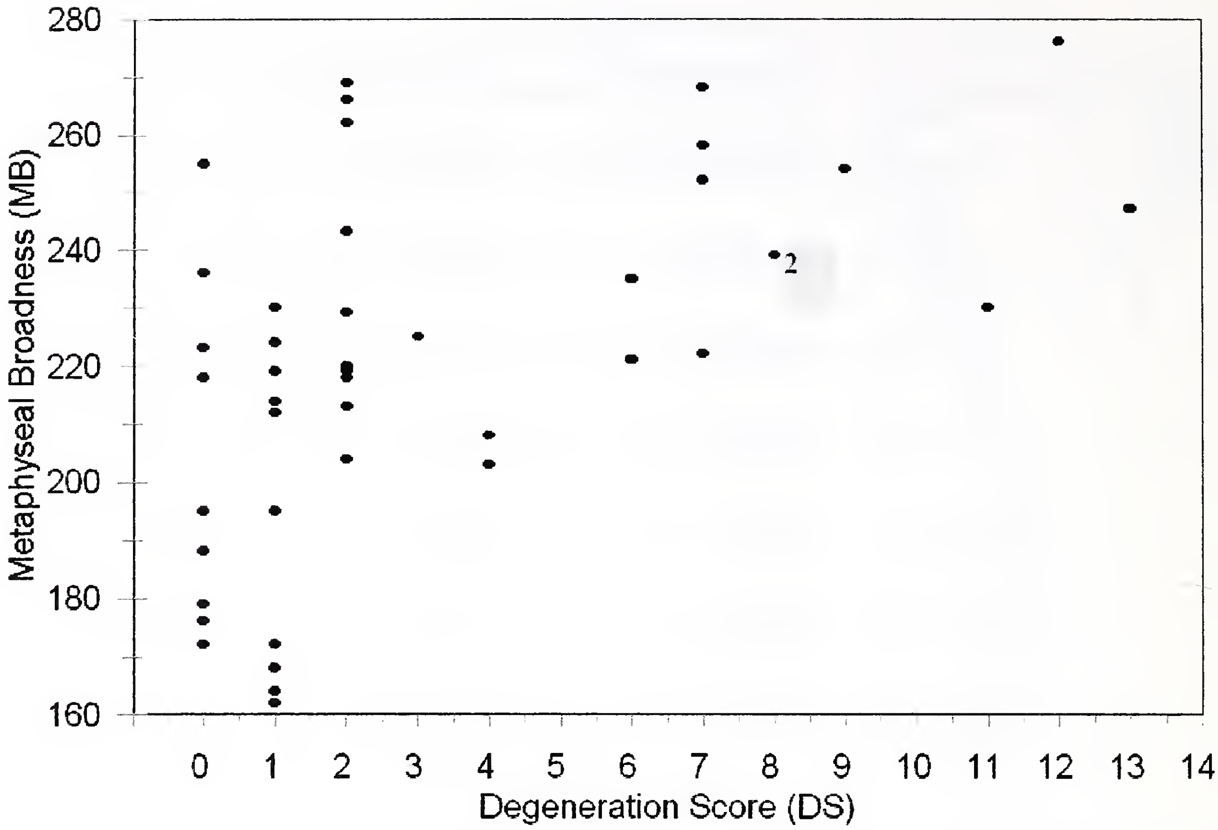

Figure 4.—Metaphyseal broadness (MB) plotted against degeneration score. Metaphyseal broadness is calculated using the formula MB = (CA-CG) + (CB-CG) + (CC-CG) + (CD-CG) + (CE-CG) + (CF-CG), where CA is the circumference at point A ($^1/_{20}$ of condyle-malleolus length distal to the plateaus), CB is the circumference at point B ($^2/_{20}$ of condyle-malleolus length distal to the plateaus), etc. Degeneration score is calculated by combining the ordinal scores of eight locations on the proximal tibia using Jurmain's (1975) method (see Table 1).

chondral bone in reaction to mechanical forces. It remains to be demonstrated that the increases in circumference described here are directly related to the mechanisms of joint degeneration and/or the history of mechanical loading. Given the nature of the sample used in this study, it was not possible to control for the age-at-death of the individuals examined. It is possible that the observed changes in the ratios of proximal tibial circumference to metaphysis length are related to a variety of factors, including cumulative mechanical loading over the life of the individual.

Internal and external pre-pathological changes of the proximal tibia are complex (White 1999). Much further research will be needed to elaborate, refine, and integrate their study. Relationships between the architecture of the trabecular bone underlying the subchondral bone of the proximal tibia and metaphyseal shape changes as measured here are unknown. There is a wider range of variation in the metaphyseal broadness measurements of "unaffected" specimens than "affected" specimens (Fig. 4). It seems plausible that the metaphyseal cortical shell of the proximal tibia may undergo stress-related changes in shape and/or size prior to the appearance of any of Jurmain's (1975) indicators. Such changes may be more apparent when finer resolution data are collected (i.e., circumference measured at a closer interval), a larger sample (controlled for age and sex) is used, more sophisticated methods of characterizing size and shape are employed, and data on internal structure and bone cross-section are incorporated. Study of the entire tibia rather than just the proximal metaphysis, as well as study of the other bones involved in the knee joint, may yield additional information.

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AN ILLUSTRATED CATALOGUE OF MACROSCOPIC SUBFOSSILS FROM LATE-PLEISTOCENE AND HOLOCENE WETLAND DEPOSITS IN NORTHERN INDIANA

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ABSTRACT. Subfossils from 16 holocene wetlands in northern Indiana were described and illustrated. A summary of the relative abundance, stratigraphic occurrence, chronology, and frequency of each taxon was presented. Approximately 57 taxa representing algae, vascular plants, mollusks, insects, and vertebrates were recorded in the survey. The subfossils range in age from recent (within 50 years before present) to 15,910 ± 90 years before present.

Recognizing the great value of peatlands and other wetland deposits as natural museums, Potzger (1936) remarked,

> In more recent times the Pleistocene not only left a trail of tell-tale relic colonies of northern plants here in Indiana, but also made its contributions to the fossil records by depositions in bogs and slowly-forming topographic features, where life records are neatly stored away as in a vast archive, preserving the story of the day when they were living forms, and linking the past to the present, partially interpreting for us the plant and animal world of today.

These subfossil remains, preserved in the wetland deposits of the region, include both microfossils, such as pollen and diatoms, and macroscopic remains, including leaves, seeds, fish scales, turtle shells, and a variety of other remains.

Although the fossil pollen from Indiana's Holocene peat deposits has received much attention, especially in the first half of the 20th century [see Swinehart (1997) for review], relatively few studies have focused on the macroscopic subfossils of Indiana's wetland deposits. Most studies on macroscopic subfossils have centered on individual sites (Potzger 1936; Friesner & Potzger 1946; Whitehead et al. 1982; Jackson et al. 1986; Swinehart & Starks 1994; Swinehart 1995a, b), and many of these were associated with the remains of ice-age megafauna. More recently, Swinehart & Parker (2000) conducted a comprehensive study of the subfossil biota of the peatlands of northern Indiana. Additionally, the Indiana State Museum has recently placed a higher priority on detailed studies of macroscopic plant subfossils associated with ice-age mammal remains (Swinehart 1996; Swinehart & Richards 2001), whereas previously these were often neglected (Richards et al. 1987; Hunt & Richards 1992).

With increased attention being devoted to macroscopic subfossils for palaeoenvironmental reconstructions, there is a need to develop resources that facilitate identification of subfossils and a need to record the stratigraphic occurrence and frequency of individual species in a given region. Determining the identity of subfossil biota is complicated by the fact that most remains are only fragments or reproductive propagules of organisms. Because most dichotomous keys and field guides focus on the descriptions of entire organisms, few resources exist that allow identification of depauperate subfossil fragments representing a variety of taxonomic phyla.

This paper summarizes the subfossil assemblages of 16 wetlands studied by the author during the past ten years. The objectives are to describe and illustrate subfossils recovered from northern Indiana wetlands and summarize their relative abundance, stratigraphic occurrence, chronology, and frequency.

METHODS

Subfossils are here defined as (1) remains of once living organisms that are composed, at least in part, of their original organic con-

Table 1.—List of sites in Indiana where macroscopic subfossils were surveyed.

Site name	Acronym	Location	County
Aker Mastodont Locality	AML	T33N, R1E, Sec. 3	Marshall
Binkley Fen	BIN	T38N, R13E, Sec. 31	Steuben
Blueberry Bog	BLB	T38N, R7E, Sec. 24	Elkhart
Bristol Fen	BRF	T38N, R6E, Sec. 26	Elkhart
Burket Bog	BUR	T32N, R5E, Sec. 20	Kosciusko
Celery Bog	CEL	T23N, R5W, Sec. 12	Tippecanoe
Dutch Street Bog	DSB	T35N, R10E, Sec. 11	Noble
Kiser Lake Fen	KLF	T33N, R7E, Sec. 13	Kosciusko
Little Arethusa Bog	LAB	T31N, R7E, Sec. 7	Kosciusko
Little Chapman Bog	LCB	T33N, R6E, Sec. 35	Kosciusko
Ropchan Memorial Bog	RMB	T38N, R12E, Sec. 22 & 23	Steuben
Shafer Mastodont Locality	SML	T23N, R6W, Sec. 7	Warren
Svoboda Fen	SVF	T35N, R11E, Sec. 8	Noble
Tamarack Bog	TAM	T35N, R9E, Sec. 7	Noble
Wilkinson Giant Beaver Locality	WBL	T31N, R8E, Sec. 14	Whitley
Yost Bog	YB	T38N, R8E, Sec. 32	Lagrange

stituents, or (2) inorganic material of biotic origin that has not yet been lithofied (i.e., mollusc shells, *Chara* tests). With the exception of *Potamogeton* achenes which were determined using the manuscript by Jessen (1955), subfossil seeds and achenes were identified using the text by Montgomery (1977). Mosses were identified with the assistance of Crum & Anderson (1981) and Janssens (1983); molluscs with the assistance of Harmen & Berg (1971). *Sphagnum* remains were not identified to species. Questionable subfossil material that seemed referable to a known taxon is preceded by the Latin abbreviation "cf." (*conferre*). Representative subfossils from each wetland were placed in vials with a 60% solution of ethanol. Voucher specimens were placed in the private museum of the author at Hillsdale College and are available for examination. Specimens were hand drawn from actual subfossil material by the author with the aid of dissecting scope and ruler.

Developmental stages of the peatlands were based on assemblages of subfossils that denoted seral stage and/or structural characteristics of the respective ecosystems and were determined by visual inspection of subfossil diagrams (see Swinehart & Parker 2000; Swinehart & Richards 2001).

A list of the sites and their general locations is presented in Table 1. Several sediment collection methods were used among the 16 sites. The general stratigraphy of each site is summarized in Fig. 1.

Ice-age mammal localities.—(Aker, Shafer, and Wilkinson deposits). A sump was excavated near the fossil mammal bones to drain water from the bone bed. Once the standing water was drained, disturbed muck was carefully removed from the site by hand, placed into buckets, and washed through a 1.2 mm mesh screen to recover possible bone fragments and other subfossils. The site was then divided into 2 m^2 units. Sediment from each unit was removed at 10 cm intervals from the top of the bone-bed to the bottom of the wetland deposit. This bulk material was washed through 1.2 mm mesh screens for recovery of macroscopic subfossils and small bones. In addition to bulk samples, smaller sediment samples were taken for the identification and quantification of smaller subfossils. A 50 cm^3 plastic container was pushed into the vertical profile of sediment adjacent to the bone bed at 10 cm intervals, beginning at the wetland surface and extending to the glacial drift at the bottom of the deposit.

Subfossils taken from screened bulk material were identified and counted. Additionally, the smaller (50 cm^3) sediment samples were carefully rinsed through a 0.2 mm mesh screen. The recovered subfossils were then identified and counted.

Celery Bog.—An Osterburg hydraulic piston corer mounted on an all-terrain vehicle was used to collect a 10 m deep core with a diameter of 10 cm. The core extended from the surface of the wetland to glacial till at the bottom. Sections of the core, collected in 3 meter-long metal sleeves, were brought to the laboratory for analysis. The metal sleeves containing the cores were hand-sawed into 10 cm sections. The sediment from each 10 cm section was examined for identifiable subfossil remains.

A standard 20 ml volume was taken from each interval and gently rinsed through a 0.4 mm mesh sieve. The material remaining in the sieve was placed in a petri dish and examined under a dissecting microscope for identification and quantification of macroscopic subfossils.

Bristol Fen & Tamarack Bog.—Sediments in Bristol Fen were collected manually with a post-hole excavator at 15 cm intervals. Blocks of peat from each depth interval were rinsed with water on a 1 mm mesh screen. Rinsed material was sorted by hand. Sediments from Tamarack Bog were recovered using a 2.5 cm diameter Hillar corer. Sediments from 20–25 cm intervals were rinsed, and subfossils were identified with the aid of a dissecting microscope. Subfossils from Bristol Fen and Tamarack Bog were not counted.

Remaining sites.—Each site was systematically probed using metal rods. Coring was conducted at the deepest probe location in each peatland. A modified Hiller corer with a chamber diameter of 5 cm was used to collect sediments. Cores were sectioned into 25 cm lengths and placed into plastic bags. A standard 20 cm^3 volume was taken from each interval and gently rinsed through a 0.4 mm mesh sieve. The material remaining in the sieve was placed in a petri dish and examined under a dissecting microscope for identification and quantification of macroscopic subfossils. The remaining sediment from each sampling interval was also rinsed through a 0.4 mm mesh sieve. The material was then placed into a white enamel pan and examined for large, infrequent subfossils such as bones, large seeds and leaves that might not have been represented in the 20 cm^3 subsamples.

Radiocarbon dating.—Selection of material at different depths for radiocarbon (^{14}C) dating was based on the developmental stages represented in subfossil diagrams (see Swinehart & Parker 2000; Swinehart & Richards 2001). Whenever possible, aquatic and wetland bryophytes were excluded from the radiocarbon samples to reduce the potential for carbon loading. The samples were treated using the Acid-Base-Acid method and were analyzed by accelerator mass spectrometry at the Purdue University Rare Isotope Measurement (PRIME) Laboratory. All results are reported in years before present (ybp) and have been corrected to Delta ^{13}C of -25PDB.

Although radiocarbon dates are not available for all depths in each peatland, most major stratigraphic units have been dated (Fig. 1). Because of the cumulatively large number of radiocarbon dates and because the dates generally occur at the strata where major changes in biota occurred, it was possible in most cases to get a general idea of the earliest dated records for each taxon among the sites in northern Indiana. For species that are currently extant in Indiana, only the oldest radiocarbon date was reported for the respective taxa. For species that are currently extinct in Indiana, both the oldest and youngest available radiocarbon dates are reported.

RESULTS

Approximately 57 taxa were represented in the survey of macroscopic subfossils from the 16 Indiana wetlands (Table 2, Figs. 2–101). The subfossils range in age from recent (within 50 ybp) to 15,910 ± 90 ybp. The following is a list and description of each taxon including a summary of the current habitat, typical condition of the subfossils, and the stratigraphic occurrence of each taxon.

Kingdom Plantae
Division Thallophyta
Class Chlorophyceae
Order Charales
Family Characeae

Chara sp.: (Figs. 2, 3). *Habitat:* Springs, ponds, and lakes with highly alkaline waters, commonly forming dense mats on sandy or marly bottoms; in open areas and protected bays, often in association with water lilies. Although most common in shallow water, plants may be found at depths of several meters. *Description:* Subfossil oogonia (Fig. 2) are usually slightly less than 0.5 mm; oval; dark brown to black in color, generally opaque when entire; raised spiraling ridges separated by concave hollows; spirals unravel in a ribbon-like fashion when struc-

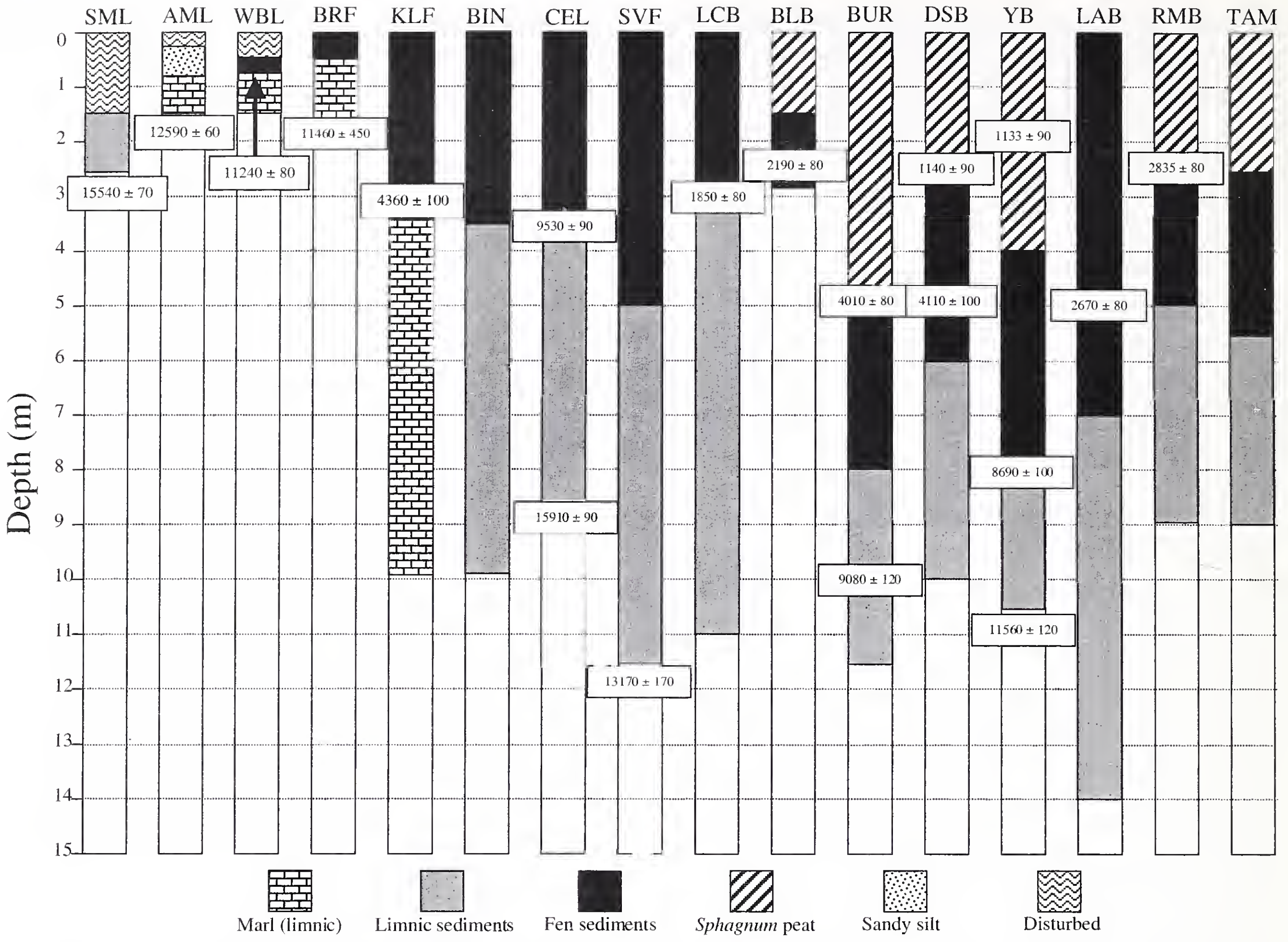


Figure 1.—General stratigraphy and associated radiocarbon dates for the 16 wetlands surveyed for macroscopic subfossils. SML = Shafer Mastodont Locality; AML = Aker Mastodont Locality; WBL = Wilkinson Giant Beaver Locality; BRF = Bristol Fen; KLF = Kiser Lake Fen; BIN = Binkley Fen; CEL = Celery Bog; SVF = Svoboda Fen; LCB = Little Chapman Bog; BLB = Blueberry Bog; BUR = Burket Bog; DSB = Dutch Street Bog; YB = Yost Bog; LAB = Little Arethusa Bog; RMB = Ropchan Memorial Bog; TAM = Tamarack Bog.

ture is damaged. Subfossil thalli (Fig. 3) are small fragments usually less than 4 mm in length; gray; lime-covered; cylindrical and sulcate; cell walls often visible at breakage points or where lime has been scraped away. *Stratigraphy:* Thalli comprised a large percentage of the marl in Kiser Lake Fen, Kosciusko County, Indiana, and were found throughout the marl stratum; vegetative thalli never found in organic sediments. Oogonia frequent in the early limnic sediments of some peatland basins, usually absent in the marsh, fen, and bog strata. *Chronology:* The oldest dated record is 12,590 ± 60 ybp (Aker Mastodont Locality). *Frequency:* 38%. *Abundance:* Frequent where found, although many of the marls lack identifiable remains of thalli.

Division Bryophyta
Subdivision Musci
Class Sphagnopsida
Order Sphagnales
Family Sphagnaceae

Sphagnum spp.: (Figs. 4–6). *Habitat:* Peatlands; in carpets or lawns and occasionally developing hummock/hollow complexes in acid conditions, restricted to isolated hummocks in more neutral to alkaline environments. *Description:* Leaf thalli (Fig. 4) light brown; composed of large, rhomboidal, hyaline cells bordered by narrow, linear cells (chlorophyllose when living); hyaline cells usually bearing large spherical or elliptical pores (Fig. 5). Occasionally, leaf thalli found attached to stem thalli (Fig. 6), but only in the uppermost, more recent sediments. *Stratigraphy:* Generally restricted to the upper 2–3 m of sediment. *Chronology:* The oldest dated record is < 9530 ± 90 ybp (Celery Bog). *Frequency:* 56%. *Abundance:* Extremely frequent where found, often comprising more than 90% of the peat.

Class Bryopsida
Order Bryales
Family Meesiaceae

Meesia triquetra: (Figs. 7–9). *Habitat:* In wet, highly alkaline, often marly areas; open fens or forested peatlands, mostly in boreal climates. No extant populations have been reported from Indiana. *Description:* Subfossils found as well-preserved fragments (Fig. 7) up to 40 mm in length; stems often radiculose; radicles dark reddish-brown in color; leaves (Fig. 8) golden to dark brown in color, keeled above shoulder, distinctly serrulate at margins (Fig. 9) from shoulders to the acute apex, cells rhomboidal to rectangular; costa pronounced, extending into the acumen. *Stratigraphy:* Found at the interface between fen peat and *Sphagnum* bog peat, always associated with *Calliergon trifarium* but in lesser quantity. *Chronology:* The youngest dated record is 59 ± 80 ybp (Little Arethusa Bog), and the oldest dated record is 4110 ± 100 ybp (Dutch Street Bog). *Frequency:* 31%. *Abundance:* Frequent where found; occurs as discrete strands.

Order Hypnobryales
Family Thuidiaceae

Thuidium delicatulum: (Figs. 10–12). *Habitat:* Moist soil and humus, most commonly on rotting logs in swamps or wet woodlands. *Description:* Fragments (Fig. 10) small, twice pinnate, dark brown in color, well preserved; primary branch leaves (Fig. 11) more or less ovate, with an acute apex (Fig. 12); costa pronounced, extending to the lower acumen, margins papillose-serrulate. *Stratigraphy:* Two fragments from basal sediments of Little Arethusa Bog. *Frequency:* 6%. *Abundance:* Extremely rare.

Family Amblystegiaceae

Campylium stellatum: (Figs. 13–15). *Habitat:* In open, wet areas of highly alkaline marshes and fens (Crum & Anderson 1981). Also found in swamps and on wet banks (Welch 1957). *Description:* Small fragments (Fig. 13) mostly less than 20 mm in length, light brown in color; leaves (Fig. 14) broad at base, narrowing to a slender, acute apex, entire, arising from stem at an acute angle, then spreading away from stem near shoulder; costa present, forked, one extension being longer than the other, often extending to midleaf; alar cells (Fig. 15) conspicuous, concentrated at leaf margin and not extending to costa. *Stratigraphy:* In sapric or hemic peat of Binkley Fen, also in silt at Wilkinson Giant Beaver Locality. *Chronology:* The oldest dated record is greater than 11,990 ± 90 ybp (Wilkinson Giant Beaver Locality). *Frequency:* 13%. *Abundance:* Rare where found, occurs as single strands.

Drepanocladus aduncus: (Figs. 16–19). *Habitat:* Wet calcareous areas including swamps marshes, sloughs, lakeshores, and sluggish streams. Most common in fens and mineral-rich lagg waters of bogs, often emergent and sometimes submergent. *Description:* Well preserved fragments (Fig. 16) up to 100 mm in length, light brown to reddish-brown in color; leaves (Fig. 17) entire, ovate-lanceolate, narrowing to a slender, channeled acumen, falcate, occasionally but not always secund, sometimes spreading in a form similar to *Amblystegium riparium*; costa pronounced, extending above midleaf; upper median cells of leaf (Fig. 18) rhomboidal-linear; alar cells (Fig. 19) somewhat conspicuous, extending from leaf margin to within three rows of cells from the costa, sometimes difficult to observe, often retained on stem when leaf is torn away. Although not characteristic of the species, the walls of the alar cells on many of the specimens are dark yellow-brown in color. *Stratigraphy:* Beginning at the upper reaches of limnic sediment and eventually forming peat, often replaced by *Calliergon trifarium* and *Meesia triquetra* before *Sphagnum* peat dominates within the top 2–3 m of the profile. *Chronology:* The oldest dated record is 13,170 ± 170 ybp (Svoboda Fen). *Frequency:* 81%. *Abundance:* Extremely abundant where found, often forming pure strata of entangled strands.

Scorpidium scorpioides: (Figs. 20–22). *Habitat:* Open fens, often submergent or emergent (Crum & Anderson 1981). *Description:* Small fragments (Fig. 20) mostly less than 10 mm in length, light brown in color, more or less prostrate; leaves (Fig. 21) oblong-ovate, somewhat imbricate; costa lacking; cells at insertion enlarged; alar cells (Fig.

Table 2.—The occurrence of subfossil taxa in 16 wetlands in northern Indiana. The wetlands types are: (1) marsh, (2) marl fen, (3) fen, (4) tall-shrub bog, (5) leatherleaf bog, and (6) forested peatland. The sites surveyed (names abbreviated below) are: Shafer Mastodont Locality, Aker Mastodont Locality, Wilkinson Giant Beaver Locality, Bristol Fen, Kiser Lake Fen, Binkley Fen, Celery Bog, Svoboda Fen, Little Chapman Bog, Blueberry Bog, Burket Bog, Dutch Street Bog, Yost Bog, Little Arethusa Bog, Ropchan Memorial Bog, and Tamarack Bog.

	Wetland type																%
Species	SML (1)	AML (2)	WBL (2)	BRF (2)	KLF (2)	BIN (3)	CEL (3)	SVF (3)	LCB (4)	BLB (4)	BUR (5)	DSB (5)	YB (5)	LAB (6)	RMB (6)	TAM (6)	Fre-quency
Algae																	
Chara sp.		X			X	X	X						X		X		38
Bryophytes																	
Sphagnum spp.							X		X	X	X	X	X	X	X	X	56
Meesia triquetra									X			X		X	X	X	31
Thuidium delicatulum														X			6
Campylium stellatum			X			X											13
Drepanocladus aduncus	X	X		X	X	X	X	X	X	X	X	X	X	X			81
Scorpidium scorpioides								X									6
Calliergon stramineum						X		X	X						X		25
Calliergon trifarium									X	X	X	X		X	X	X	44
Polytrichum strictum													X				6
Conifers																	
Picea glauca	X	X	X	X													25
Picea mariana		X		X													19
Picea sp.	X									X							13
Larix laricina	X	X	X			X	X			X				X	X	X	56
Abies balsamea			X				X			X							19
Angiosperms																	
Potamogeton spp.	X	X	X	X		X	X			X	X	X	X	X		X	75
Najas flexilis	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	94
Eleocharis sp.		X					X						X				19
Scirpus subterminalis													X				6
Scirpus acutus-type		X	X		X	X	X		X	X	X	X	X	X	X	X	81
Carex cf. *pseudocyperus*										X							6
Carex spp.		X	X		X		X		X		X				X	X	50
Dulichium arundinaceum									X		X		X				13
Fuirena pumila													X				6

Table 2.—Continued.

	Wetland type																%
Species	SML (1)	AML (2)	WBL (2)	BRF (2)	KLF (2)	BIN (3)	CEL (3)	SVF (3)	LCB (4)	BLB (4)	BUR (5)	DSB (5)	YB (5)	LAB (6)	RMB (6)	TAM (6)	Frequency
Ceratophyllum demersum	X				X		X	X	X		X	X		X			50
Nuphar advena			X	X				X	X		X	X		X	X		50
Nymphaea odorata			X						X	X	X		X				31
Brasenia schreberi			X			X	X		X	X	X	X	X	X			56
Sarracenia purpurea												X					6
Impatiens capensis								X									6
Myriophyllum exalbescens	X																6
Andromeda glaucophylla											X		X	X	X	X	31
Chamaedaphne calyculata											X	X	X				19
Vaccinium macrocarpon						X			X		X	X		X	X	X	44
Menyanthes trifoliata									X		X	X	X		X		31
Bidens sp.									X								6
Molluscs																	
Physa sayii			X		X												13
Lymnaea humilis		X	X	X	X												25
Lymnaea haldemani			X	X													13
Helisoma anceps			X	X	X												19
Helisoma campanulata			X	X	X												19
Gyraulus parvus		X	X	X	X				X								31
Pleurocera acuta					X												6
Amnicola limosa			X	X	X												19
Amnicola lustrica		X	X	X	X												25
Valvata tricarinata		X	X	X	X												25
Valvata sincera			X	X	X		X										25
Gastrocopta sp.					X												6
Retinella sp.					X												6
Helicodiscus parallelus			X														6
cf. *Elliptio dilatata*			X														6
Sphaerium sp.			X	X													13
Pisidium sp.		X	X	X	X								X	X			38

Table 2.—Continued.

Species	Wetland type																%
	SML (1)	AML (2)	WBL (2)	BRF (2)	KLF (2)	BIN (3)	CEL (3)	SVF (3)	LCB (4)	BLB (4)	BUR (5)	DSB (5)	YB (5)	LAB (6)	RMB (6)	TAM (6)	Frequency
Insects																	
Coleoptera					X	X	X		X	X	X		X	X	X	X	63
cf. *Micrasema* sp.								X									6
Fishes																	
Percidae									X								6
Centrarchidae					X				X					X			19
Reptiles																	
Sternotherus odoratus									X								6

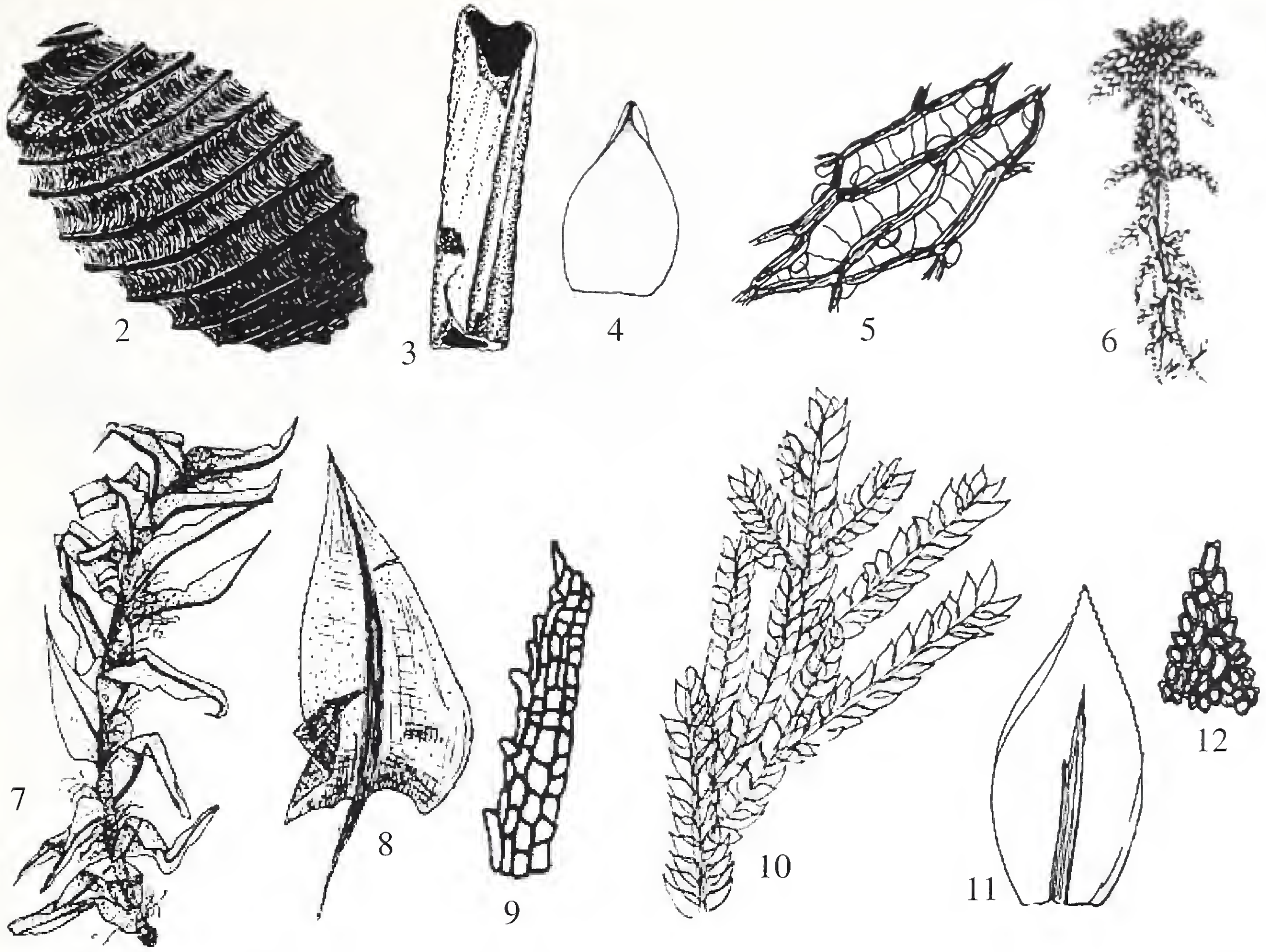
22) somewhat inconspicuous. *Stratigraphy:* Deep in the hemic peat of Svoboda Fen. *Chronology:* The oldest record is 13,170 ± 170 ybp (Svoboda Fen). *Frequency:* 6%. *Abundance:* Extremeley rare.

Calliergon stramineum: (Figs. 23–25). *Habitat:* Open, rich fens and sedge meadows, laggs (Crum & Anderson 1981). Extant populations have not been reported from Indiana. *Description:* Small shreaded fragments (Fig. 23) less than 10 mm in length, reddish-brown; leaves (Fig. 24) oblong, entire, imbricate, decurrent, more or less spreading; costa pronounced, extending to the apex; walls of cells at leaf base thickened; alar cells (Fig. 25) conspicuous, concentrated at the leaf margin and not extending to the costa. *Stratigraphy:* In hemic peat (fen stratum) between limnic sediments and *Sphagnum* peat. *Chronology:* The most recent dated record is 2835 ± 80 ybp (Ropchan Memorial Bog), and the oldest record is greater than 3680 ± 80 ybp (Little Chapman Bog). *Frequency:* 25%. *Abundance:* Rare where found; occurs as single small fragments.

Calliergon trifarium: (Figs. 26–29): *Habitat:* Highly alkaline, wet-fen habitats, often found as strands among other mosses and sedges (Crum & Anderson 1981). Extant populations have not been reported from Indiana. *Description:* Well preserved fragments (Fig. 26) up to 30 mm in length, terete, light brown in color; leaves (Fig. 27) elliptic to oblong, entire, imbricate, crowded and apressed at base of stem, somewhat loose spreading near tips (Fig. 28); costa present, about two-thirds the length of the leaf; alar cells (Fig. 29) enlarged, extending from leaf margin to costa. *Stratigraphy:* Found at the interface between fen peat (dominated by *Drepanocladus aduncus*) and *Sphagnum* peat. Almost always associated with *Meesia triquetra*. *Chronology:* The most recent dated record is 45 ± 80 ybp (Little Chapman Bog), and the oldest dated record is 4010 ± 80 ybp (Burket Bog). *Frequency:* 44%. *Abundance:* Extremely frequent where found, often comprising a large portion of the total volume of peat.

Family Polytrichaceae

Polytrichum strictum: (Figs. 30, 31). *Habitat:* On the dry tops of *Sphagnum* hummocks in bogs. *Description:* Well preserved fragments (Fig. 30) up to 40 mm in length, auburn



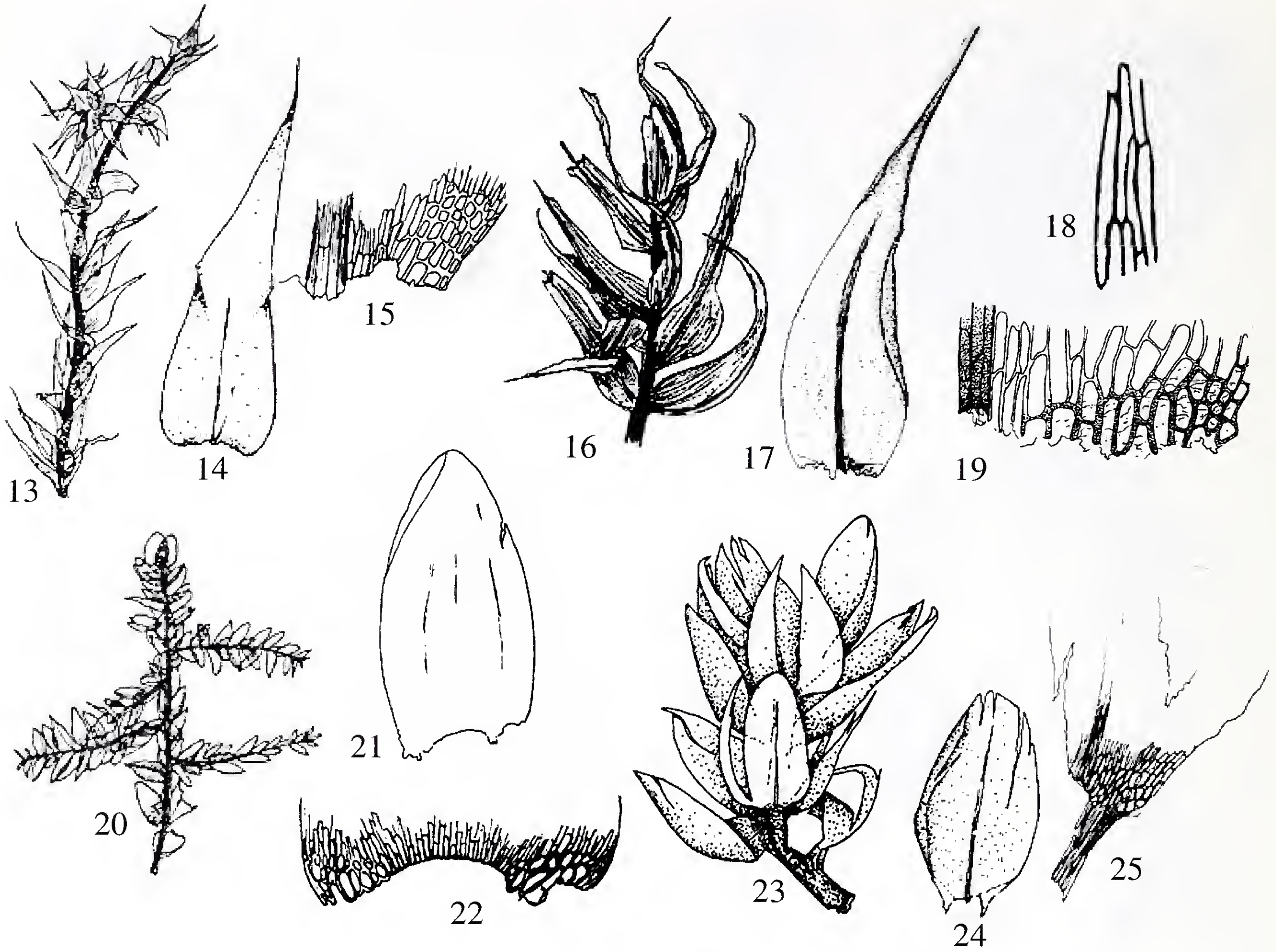
Figures 2–12.—2. *Chara* sp. oogonium (0.4 mm); 3. *Chara* sp. calcified stem-thallus (4 mm); 4. *Sphagnum* sp. branch leaf (2 mm); 5. *Sphagnum* sp. branch leaf cells; 6. *Sphagnum* sp. stem fragment with branches and leaves (9 cm); 7. *Meesia triquetra* stem fragment with leaves and radicles (20 mm); 8. *M. triquetra* leaf (3.5 mm); 9. Margin of leaf of *M. triquetra* showing serration; 10. *Thuidium delicatulum* fragment (4 mm); 11. *T. delicatulum* leaf (0.5 mm); 12. Apex of leaf of *T. delicatulum*.

in color; leaves (Fig. 31) straight and erect, base broad, becoming lanceolate and in-folded above shoulders, ending in a toothed awn, cells at shoulder laterally elongate and cramped; costa pronounced, excurrent, bearing lamellae. *Stratigraphy:* In upper layers of *Sphagnum* peat stratum in Yost Bog, Lagrange County, Indiana. *Frequency:* 6%. *Abundance:* Frequent in Yost Bog as individual strands in *Sphagnum* peat.

Division Spermatophyta
Subdivision Gymnospermae
Order Coniferales
Family Pinaceae

Picea glauca: (Figs. 32, 34). *Habitat:* Well-drained coniferous swamps, lakeshores and stream borders, mixed forests (Voss 1972), and occasionally in peatlands; mostly in boreal climates. Extinct in Indiana. *Description:* Cones (Fig. 32) well preserved, elongate 30–50 mm in diameter; seeds intact within axles of scales; leaves (Fig. 34) fragmented, poorly preserved, mostly apices, thick, four-angled in cross-section, not distinguished from *P. mariana*. *Stratigraphy:* In deeper sediments of silt and especially marl deposits. *Chronology:* The most recent dated record is 11,240 ± 80 ybp (Wilkinson Giant Beaver Locality), and the oldest dated record is 15,540 ± 70 ybp (Shafer Mastodont Locality). A piece of spruce wood dating 15,910 ± 90 ybp from the basal sediments of Celery Bog is probably *Picea glauca*, but the specific species cannot be determined definitively. *Frequency:* 25%. *Abundance:* Cones and leaves infrequent where found.

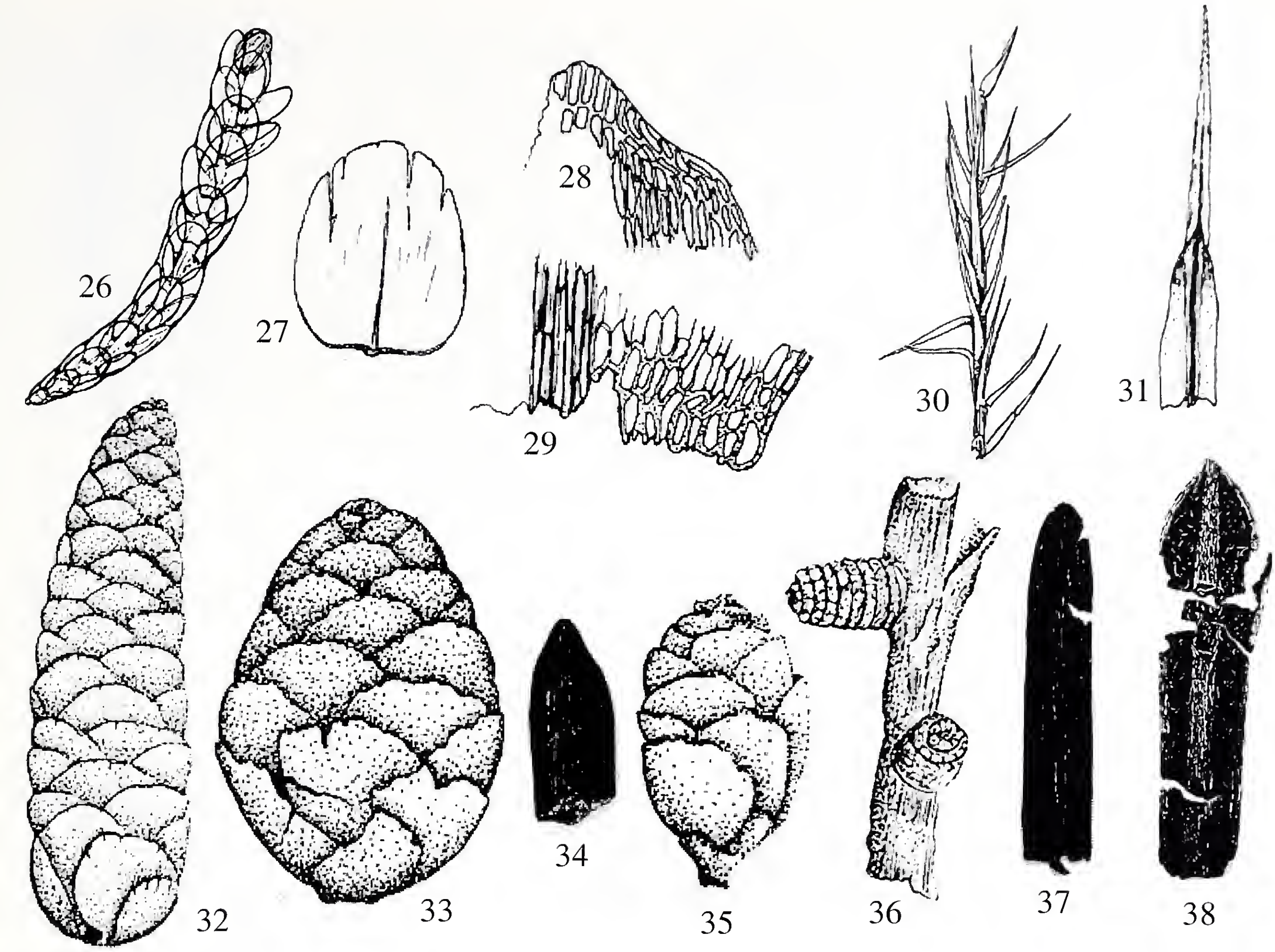
Picea mariana: (Figs. 33, 34). *Habitat:* In wet, often nutrient-poor areas such as swamps, low lakeshores, and bogs. In the southern portions of its range, it is restricted entirely to bogs. Extinct in Indiana. *Descrip-*



Figures 13–25.—13. *Campylium stellatum* fragment (15 mm); 14. Leaf of *C. stellatum* (2.5 mm); 15. Alar cells of *C. stellatum*; 16. *Drepanocladus aduncus* fragment (10 mm); 17. Leaf of *D. aduncus* (3.5 mm); 18. Median leaf cells of *D. aduncus*; 19. Alar cells of *D. aduncus*; 20. *Scorpidium scorpioides* fragment (10 mm); 21. Leaf of *S. scorpioides* (2 mm); 22. Base of leaf of *S. scorpioides* showing alar cells; 23. *Calliergon stramineum* fragment (8 mm); 24. Leaf of *C. stramineum* (1.5 mm); 25. Portion of leaf base of *C. stramineum* showing alar cells.

tion: Cones (Fig. 33) well-preserved, ovate-obovate, 15–30 mm in length; seeds intact within axels of scales; leaves (Fig. 34) fragmented, poorly preserved, mostly apices, thick, four-angled in cross-section, not distinguished from *P. glauca. Stratigraphy:* In peaty marl. *Chronology:* The most recent dated record is 11,460 ± 450 ybp (Bristol Fen), and the oldest dated record is 15,590 ± 60 ybp (Aker Mastodont Locality). *Frequency:* 19%. *Abundance:* Cones and leaves infrequent where found.

Larix laricina: (Figs. 35–37). *Habitat:* Swamps, lakeshores and stream borders, fens, and bogs. Restricted to peatlands in the southern portions of its range. Pioneering opportunists, they prefer open areas where competition for light with other trees is minimal. *Description:* Cones (Fig. 35) poorly preserved, fragile, stalked; twigs (Fig. 36) bearing woody spurs with many annual whorls of leaf scars; spurs seem to be more decay resistant due to dense xylem; leaves (Fig. 37) well preserved at least in hemic and fibric peat, compressed, brown in color, blades translucent when viewed under lighted dissecting scope, gradually thinning from midrib to leaf margin. *Stratigraphy:* Most common in brown moss peats, less common in *Sphagnum*. Abundant *Larix* macrofossils were found only in peatlands that are currently dominated by tamarack (with the exception of the Aker, Wilkinson, and Shafer localities which have been anthropogenically altered), suggesting that tamarack bogs may have a unique developmental history and ecology. *Chronology:* The oldest dated record is 15,540 ± 70 ybp (Shafer Mastodont Locality). *Frequency:* 56%.



Figures 26–38.—26. *Calliergon trifarium* fragment (8 mm); 27. Leaf of *C. trifarium* (1.2 mm); 28. Apex of *C. trifarium* leaf; 29. Portion of leaf base of *C. trifarium* showing alar cells; 30. *Polytrichum strictum* fragment (21 mm); 31. Leaf of *P. strictum* (4 mm); 32. *Picea glauca* cone (44 mm); 33. *Picea mariana* cone (25 mm); 34. *Picea* sp. leaf fragment (1 mm); 35. *Larix laricina* cone (16 mm); 36. Twig of *L. laricina* (11 mm); 37. Leaf of *L. laricina* (4 mm); 38. *Abies balsamea* leaf (6 mm).

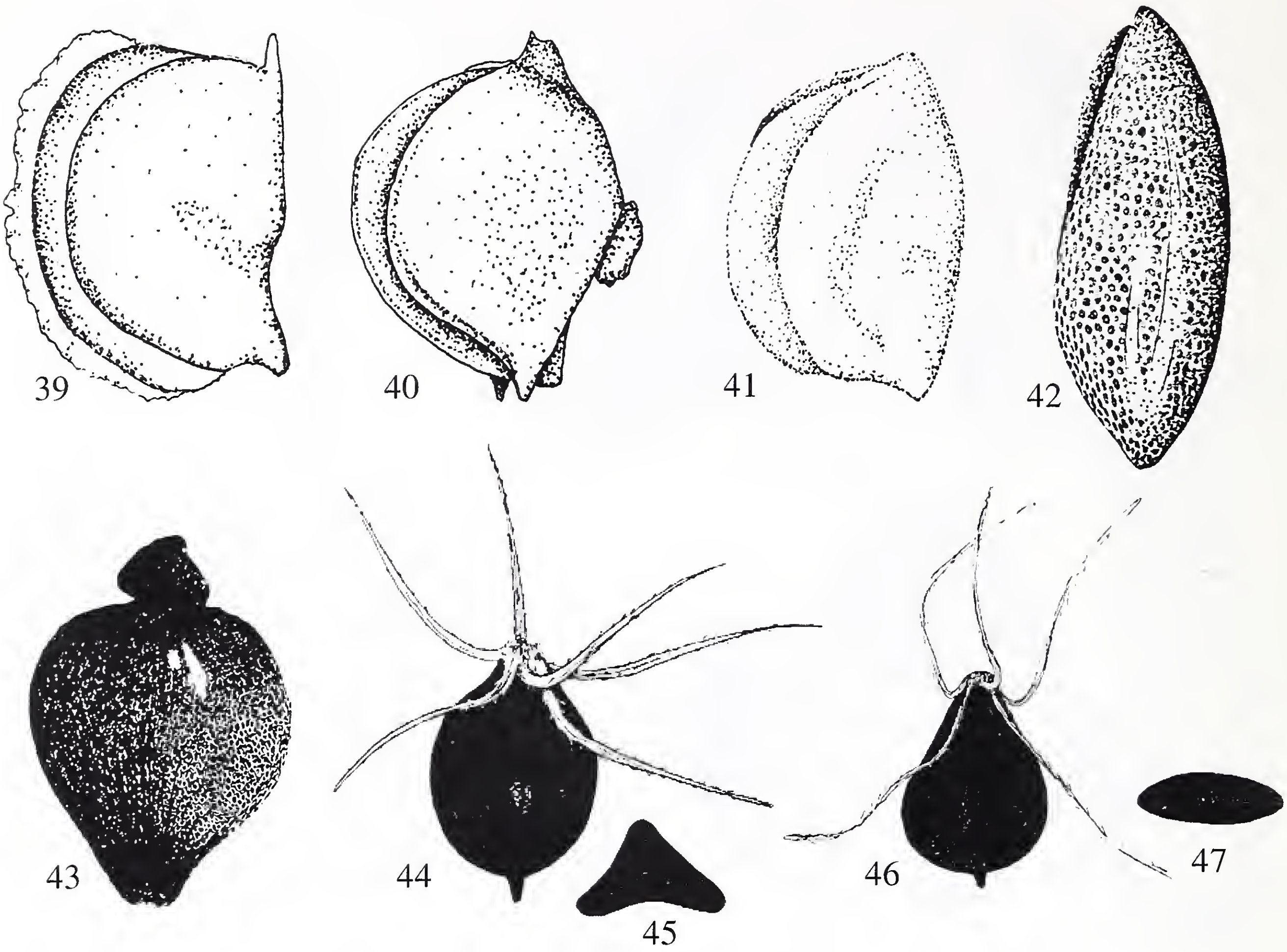
Abundance: Leaves frequent where found; cones and twigs rare; spurs were abundant in limnic sediments at the Shafer Mastodont locality, infrequent to rare at other localities.

Abies balsamea: (Fig. 38). *Habitat:* Coniferous and mixed forests; occasionally in cedar swamps, fens, and bogs. *Description:* Leaves (Fig. 38) often well preserved, though seldom entire, dark brown, thick, opaque even when observed with a lighted dissecting scope, somewhat revolute near petiole, in-folded margins compress to a thickening along the majority of the blade, midrib raised on both sides. *Stratigraphy:* Lower strata; most common in marl. *Chronology:* The only dated record is 15,910 ybp (Celery Bog). *Frequency:* 19%. *Abundance:* Leaves frequent where found; cones have not yet been found and are likely very rare in lake and wetland deposits.

Subdivision Angiospermae
Class Monocotyledoneae
Order Najadales
Family Potamogetonaceae

Potamogeton praelongus: (Fig. 39). *Habitat:* Lakes, in water up to 7 m (Voss 1972), in clear waters, often associated with *Ceratophyllum demersum*, *Najas flexilis*, *Potamogeton amplifolius*, *P. gramineus*, *P. natans*, *P. pectinatus*, and *P. robbinsii* (Swink & Wilhelm 1994). *Description:* Opercle of achene keeled and winged, ventral margin wavy, beak ventral. *Stratigraphy:* In marl, Wilkinson Giant Beaver Locality, Whitley County. *Abundance:* Infrequent to frequent where found.

Potamogeton obtusifolius: (Fig. 40). *Habitat:* Lakes and ponds. *Description:* Achene (Fig. 40) bearing two projections at base, opercle more or less keeled, sides convex. *Stra-*



Figures 39–47.—39. *Potamogeton praelongus* achene (4 mm); 40. *Potamogeton obtusifolius* achene (2.5 mm); 41. *Potamogeton pusillus* achene (1.3 mm); 42. *Najas flexilis* achene (2.5 mm); 43. *Eleocharis* sp. achene (1.8 mm); 44. *Scirpus subterminalis* achene with bristles (3 mm); 45. *S. subterminalis* achene (c.s.); 46. *Scirpus* cf. *S. acutus* achene with bristles (2 mm); 47. *S. acutus* achene (c.s.).

tigraphy: In marl, Wilkinson Giant Beaver Locality, Whitley County. *Abundance:* Infrequent to frequent where found.

Potamogeton pusillus: (Fig. 41). *Habitat:* Lakes and ponds and occasionally quiet waters of streams, in shallow waters less than 2 m (Voss 1972), prefers calcareous waters, often associated with *Elodea canadensis*, *Myriophyllum exalbescens*, *Najas flexilis*, *Nuphar advena*, *Potamogeton natans*, *P. nodosus*, *P. pectinatus*, *P. zosteriformis*, and *Vallisneria americana* (Swink & Wilhelm 1994). *Description:* Small, well-preserved, relatively smooth achenes (Fig. 41), yellow-brown in color. *Stratigraphy:* Limnic sediments, including marl. *Chronology:* The oldest dated record is 15,540 ± 70 ybp (Shafer Mastodont Locality). *Abundance:* Infrequent to frequent where found.

Family Najadaceae

Najas flexilis: (Fig. 42). *Habitat:* Extremely common in lakes, ponds, marshes, sloughs, rivers and streams. Also found on soft bottoms of open waters in peatlands. Commonly associated with *Ceratophyllum demersum*, *Elodea canadensis*, *Lemna minor*, *Myriophyllum exalbescens*, *Potamogeton foliosus*, *P. natans*, *P. nodosus*, *P. pectinatus*, and *Vallisneria americana* (Swink & Wilhelm 1994). Fruits abundantly. *Description:* Achenes (Fig. 42) extremely well preserved, fusiform, glossy, mostly reddish in color but varying from gray to light brown or yellowish, surface slightly alveolate when viewed under magnification. *Stratigraphy:* Characteristic of limnic sediments, in silt, clay, gyttja, and marl. *Chronology:* The oldest dated record is 15,540 ± 70 ybp (Shafer Mastodont Locality). *Frequency:* 94%. *Abundance:* Extremely frequent, probably the most common and numerous macrofossil in aquatic sediments. Found in almost every deposit, including humified material. Present in similar abundance in recent lake sediments of Bear Lake, Noble County, Indiana, Spotted Turtle Pond, Elkhart County, Indiana, and other extant, eutrophic lakes and ponds.

Family Cyperaceae

Eleocharis sp.: (Fig. 43). *Habitat:* Lake and pond shores, stream borders, bogs and fens, marshes, swamps, and wet depressions. *Description:* Achenes (Fig. 43) small, less than 2 mm, black in color, glossy, somewhat alveolate. *Stratigraphy:* Hemic peat. *Chronology:* The oldest dated record is 12,070 ± 50 (Aker Mastodont Locality). *Frequency:* 19%. *Abundance:* Rare where found.

Scirpus subterminalis: (Figs. 44, 45). *Habitat:* In water to 1 m in lakes, ponds, peatland pools, and rivers; on sand, muck, marl, or peat (Voss 1972); usually calcareous habitats often with *Scirpus validus* (Swink & Wilhelm 1994). *Description:* Achenes (Fig. 44) well preserved, more or less elliptical in long section tapering abruptly to a sharp style, three-angled/triangular in cross section (Fig. 45), 6 bristles bearing antrorsed teeth. *Stratigraphy:* In hemic peat of Yost Bog. *Frequency:* 6%. *Abundance:* Infrequent where found.

Scirpus acutus-type: (Figs. 46, 47). *Habitat:* In shallow water or wet areas around lakes, ponds, marshes, and flowing waters; also found in fens and marl flats. *S. validus* which has a similar achene grows in similar habitats. *Description:* Achenes (Fig. 46) well-preserved although bristles often lacking, black in color, tear-shaped in long section ending in a short pointed style, oval and compressed in cross section (Fig. 47); bristles bearing retrorsed teeth. *Stratigraphy:* Beginning at the transition from limnic sediments to marsh and fen sediments and may occur throughout the fen stratum. Generally absent from *Sphagnum* peat. *Chronology:* The oldest dated record is 12,590 ± 60 ybp (Aker Mastodont Locality). *Frequency:* 81%. *Abundance:* Variable from infrequent to frequent where found; extremely frequent at the Wilkinson Giant Beaver locality, Kosciusko County, Indiana.

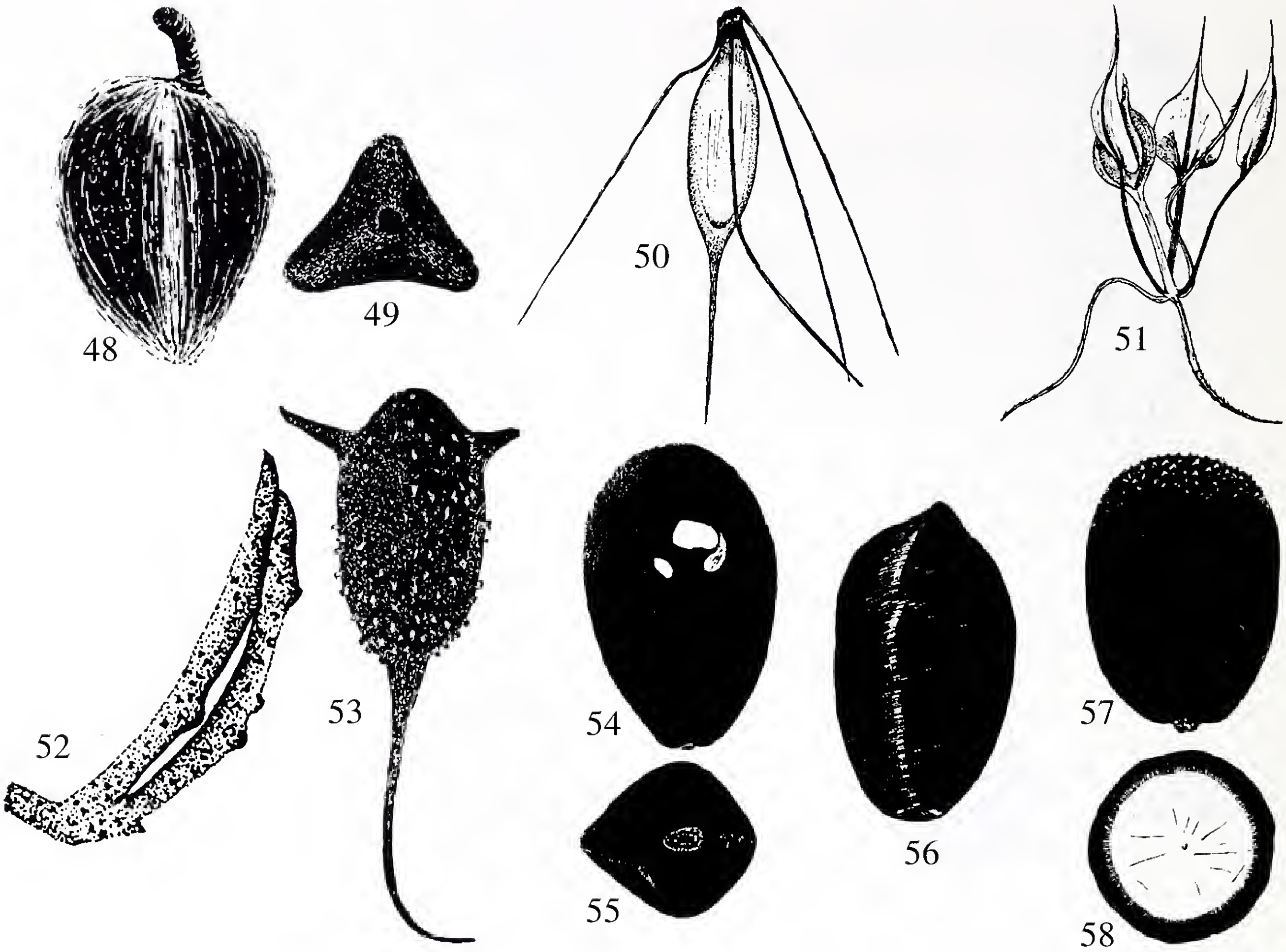
Carex cf. *pseudo-cyperus*: (Figs. 48, 49). *Habitat:* In shallow water or wet areas around lakes, ponds, marshes, and streams; also in swamps and bogs. *Description:* Achenes (Fig. 48) well preserved, lacking bristles, obovate in long section ending in a retrorsed cylindrical style, three-angled/triangular in cross-section (Fig. 49), surface somewhat alveolate. *Stratigraphy:* In sedge peat in Blueberry Bog, Elkhart County, Indiana. *Chronology:* The only dated record is 2190 ± 80 ybp (Blueberry Bog). *Frequency:* 6%. *Abundance:* Infrequent where found.

Dulichium arundinaceum: (Fig. 50). *Habitat:* Marshes, fens, and mineral-rich areas of bogs; often forming treacherous floating mats. *Description:* Achenes (Fig. 50) more or less fusiform, ending in a long narrow style, light brown in color, glabrous, somewhat translucent; bristles bend toward style and lack teeth. *Stratigraphy:* In fen strata. *Chronology:* The only dated record is 1850 ± 80 ybp (Little Chapman Bog). *Frequency:* 19%. *Abundance:* Rare where found.

Fuirena pumila: (Fig. 51). *Habitat:* Mud flats around lakes and ponds; floating mats of fens. *Description:* Fruits well preserved, light brown; Achenes (Fig. 51) more or less fusiform in long section, three-angled/triangular in cross section, stalked, ending in a short acute style; bristles three, bearing retrorsed teeth; bracts three, thickened, chordate with long, acuminate tips. *Stratigraphy:* In lower layers of *Sphagnum* peat, Yost Bog, Lagrange County, Indiana. *Frequency:* 6%. *Abundance:* Infrequent where found.

Class Dicotyledonaceae
Order Ranunculales
Family Ceratophyllaceae

Ceratophyllum demersum: (Figs. 52–53). *Habitat:* Submergent in quiet waters of lakes, ponds, sloughs, and streams. Prefers calcareous waters (Swink & Wilhelm 1994). *Description:* Leaves (Fig. 52) well preserved, light brown with dark brown spots, translucent, flattened from compression by sediment, often forked, bearing several teeth on lower margin; achenes (Fig. 53) oblong with two protruding spines and a long thin style, bearing many light brown scaly protrusions on main body. *Stratigraphy:* Restricted to the lower layers of limnic sediment; associated with *Najas flexilis* and occasionally with other aquatics such as *Potamogeton* spp. *Chronology:* The oldest dated record is 13,170 ± 170 ybp (Svoboda Fen). *Frequency:* 50%. *Abundance:* Leaves frequent to extremely frequent where found; achenes rare, not always present with leaves.



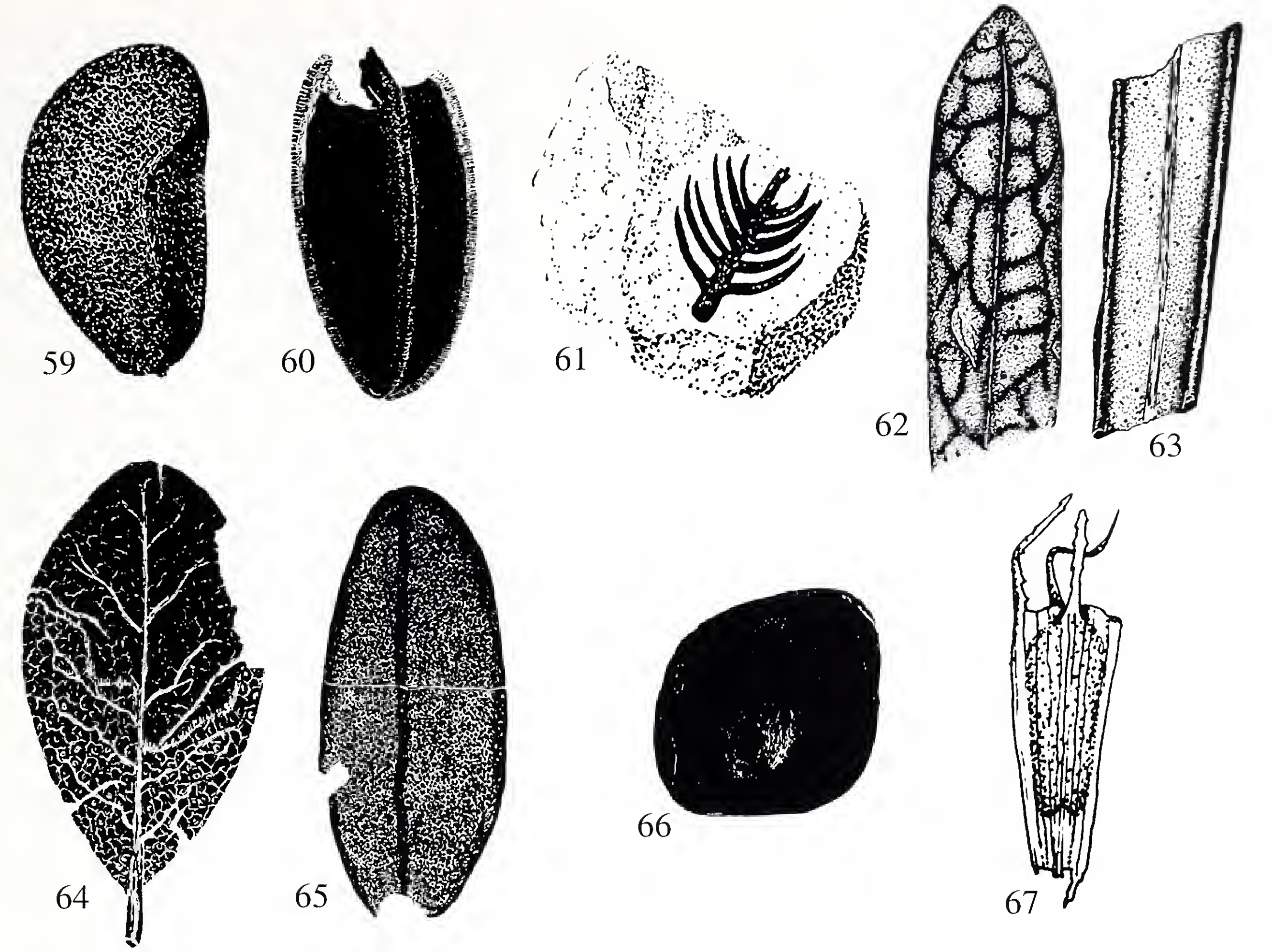
Figures 48–58.—48. *Carex* cf. *C. pseudocyperus* achene (3 mm); 49. *C. cyperus* achene (c.s.); 50. *Dulichium arundinaceum* achene with bristles (3 mm); 51. *Fuirena pumila* achene with bristles and bracts (3 mm); 52. *Ceratophyllum demersum* leaf (5 mm); 53. *C. demersum* achene (12 mm); 54. *Nuphar advena* seed (6 mm); 55. *N. advena* seed (end view); 56. *Nymphaea* cf. *N. odorata* seed (4 mm); 57. *Brasenia schreberi* seed (4 mm); 58. Cross-section of *B. schreberi* showing endosperm.

Family Nymphaceae

Nuphar advena: (Figs. 54, 55). *Habitat:* Emergent in quiet waters of lakes, ponds, rivers, and streams. Often associated with *Brasenia schreberi*, *Ceratophyllum demersum*, *Lemna minor*, *Nymphaea tuberosa*, and *Pontedaria cordata*. *Description:* Seeds (Fig. 54) obovate, usually black but occasionally brown, auburn, or yellowish in color, glossy, commonly bearing a slight "keel" (Fig. 55) but not as pronounced as in *Nymphaea odorata*. *Stratigraphy:* Transitional stratum between limnic sediments and fen peat; occasionally found well within fen and bog strata, presumably from remnant plants surviving within an advancing floating mat. *Chronology:* The oldest dated record is 11,990 ± 90 ybp (Wilkinson Giant Beaver Locality). *Frequency:* 50%. *Abundance:* Infrequent to rare where found.

Nymphaea odorata-type: (Fig. 56). *Habitat:* Emergent in quiet, shallow water of lakes, ponds, rivers and streams. Often associated with *Brasenia schreberi*, *Ceratophyllum demersum*, *Lemna minor*, *Najas flexilis*, *Nuphar advena*, and *Pontedaria cordata*. *Description:* Seeds (Fig. 56) oblong , slightly keeled, black in color, dull. *Stratigraphy:* Transitional stratum between limnic sediments and fen peat; occasionally found well within fen and bog strata, presumably from remnant plants surviving within an advancing floating mat. *Chronology:* The oldest dated record is 11,990 ± 90 ybp (Wilkinson Giant Beaver Locality). *Frequency:* 31%. *Abundance:* Infrequent to rare where found.

Brasenia schreberi: (Figs. 57, 58). *Habitat:* Quiet ponds and lakes, usually in soft, acid waters (Voss 1972); commonly associated with *Elodea canadensis*, *Lemna minor*, *Myriophyllum exalbescens*, *Nuphar advena*, *Nymphaea odorata*, *Polygonom amphibium*,



Figures 59–67.—59. *Sarracenia purpurea* seed (2 mm); 60. *Impatiens capensis* seed (5 mm); 61. *Myriophyllum exalbescens* embedded in silt clod (7 mm); 62. *Andromeda glaucophylla* upper side of leaf (30 mm); 63. *A. glaucophylla* lower side of leaf; 64. *Chamaedaphne calyculata* leaf (30 mm); 65. *Vaccinium macrocarpon* leaf (4.5 mm); 66. *Menyanthes trifoliata* achene (3 mm); 67. *Bidens* sp. achene (4.5 mm).

Pontedaria cordata, *Potamogeton pectinatus*, *Spirodela polyrhiza*, and *Utricularia vulgaris* (Swink & Wilhelm 1994). *Description:* Seeds (Fig. 57) oblong, bearing conspicuous micropyle at narrow end, opposite end is papillose; seed coat thick, woody, comprising nearly 20–25% of the diameter of the seed; empty individuals are dark brown to black in color, some specimens are reddish in color due to the reflectance of white endosperm within the seed; examination of endosperm from seeds shows cells intact; embryo present (Fig. 58); probably viable. *Stratigraphy:* Most common in the transitional marsh sediments between the limnic stratum and fen peat; usually with other emergents such as *Nuphar advena*; specimens bearing endosperm have been found to depths up to 6 m; as many as 20% of specimens contain endosperm in some deposits. *Chronology:* The oldest dated record is 11,240 ± 80 ybp (Wilkinson Giant Beaver Locality). *Frequency:* 56%. *Abundance:* Infrequent to rare, although it is not uncommon to find 40–50 seeds in a 300 cm^3 volume of sediment.

Order Sarraceniales
Family Sarraceniaceae

Sarracenia purpurea: (Fig. 59). *Habitat:* Bogs and fens. *Description:* Seeds (Fig. 59) poorly preserved, somewhat kidney shaped, brown in color, bordered on one side by a compressed "keel." *Stratigraphy:* In *Sphagnum* peat. *Chronology:* The only dated record is 1140 ± 90 ybp (Dutch Street Bog). *Frequency:* 6%. *Abundance:* Extremely rare; only one specimen found in Dutch Street Bog.

Order Sapindales
Family Balsaminaceae

Impatiens capensis: (Fig. 60). *Habitat:* Moist woods, swamps, floodplains, marshes, fens, lakeshores. *Description:* Seeds (Fig. 60) oblong in long section, compressed-oblong in cross section, black in color, bearing a narrow winged margin; seed bisected by a narrow ridge. *Stratigraphy:* In hemic peat of Svoboda Fen. *Frequency:* 6%. *Abundance:* Extremely rare; description based on a single specimen.

Order Myrtales
Family Haloragidaceae

Myriophyllum exalbescens: (Fig. 61). *Habitat:* Quiet, often calcareous waters of ponds and lakes; commonly associated with *Ceratophyllum demersum*, *Elodea canadensis*, *Lemna minor*, *Najas flexilis*, *Nuphar advena*, *Nymphaea odorata*, *Potamogeton foliosus*, *P. illinoensis*, *P. natans*, *P. pectinatus*, *P. zosteriformis*, *Ranunculus longirostris*, and *Vallisneria americana* (Swink & Wilhelm 1994). *Description:* Leaves brittle, dark brown in color, entire specimens rare, often evidenced only by carbonized imprints in silt (Fig. 61), leaf segments usually less than 12 pairs. *Stratigraphy:* In fine organic sediments of lower strata at the Shafer Mastodont Locality. *Chronology:* The only dated record is 15,540 ± 70 ybp (Shafer Mastodont Locality). *Frequency:* 6%. *Abundance:* Frequent where found.

Order Ericales
Family Ericaceae

Andromeda glaucophylla: (Figs. 62, 63). *Habitat:* Most common in leatherleaf (*Chamaedaphne calyculata*) bogs, but may also occur in fens. Associates include *Betula pumila*, *Chamaedaphne calyculata*, *Thelypteris palustris*, *Hypericum virginicum*, *Menyanthes trifoliata*, *Potentilla palustris*, *Sarracenia purpurea*, *Vaccinium macrocarpon*, and *V. oxycoccos*. *Description:* Leaves (Figs. 62, 63) brown, linear, entire, revolute; surface glabrous, covered with black flecks, veins furrowed; undersides (Fig. 63) dull with raised midrib. *Stratigraphy:* Beginning at the transition from fen peat to *Sphagnum* peat and extending well into the *Sphagnum* peat. *Chronology:* The oldest dated record is 2835 ybp (Ropchan Memorial Bog). *Frequency:* 31%. *Abundance:* Infrequent to rare where found.

Chamaedaphne calyculata: (Fig. 64). *Habitat:* Mature *Sphagnum* bogs; usually associated with *Vaccinium macrocarpon* and/or *Vaccinium oxycoccos*. *Description:* Leaves (Fig. 64) poorly preserved, obovate, entire, covered with a thick cuticle bearing pits, pits absent where cuticle has deteriorated. *Stratigraphy:* Upper layers of *Sphagnum* peat. *Chronology:* The oldest record is 4010 ± 80 ybp (Burket Bog). *Frequency:* 19%. *Abundance:* Infrequent to rare where found.

Vaccinium macrocarpon: (Fig. 65). *Habitat:* Bogs and fens; often associated with *Sphagnum*, *Chamaedaphne calyculata*, and *Sarracenia purpurea*. *Description:* Leaves (Fig. 65) well preserved, oblong, thick, dark brown to black in color, midrib visible, other veins inconspicuous, margins of leaf slightly revolute. *Stratigraphy:* Upper reaches of brown moss (fen) peat and extending through the lower layers of *Sphagnum* peat. *Chronology:* The oldest dated record is 4110 ± 100 ybp (Dutch Street Bog). *Frequency:* 44%. *Abundance:* Frequent where found.

Order Gentianales
Family Gentianaceae

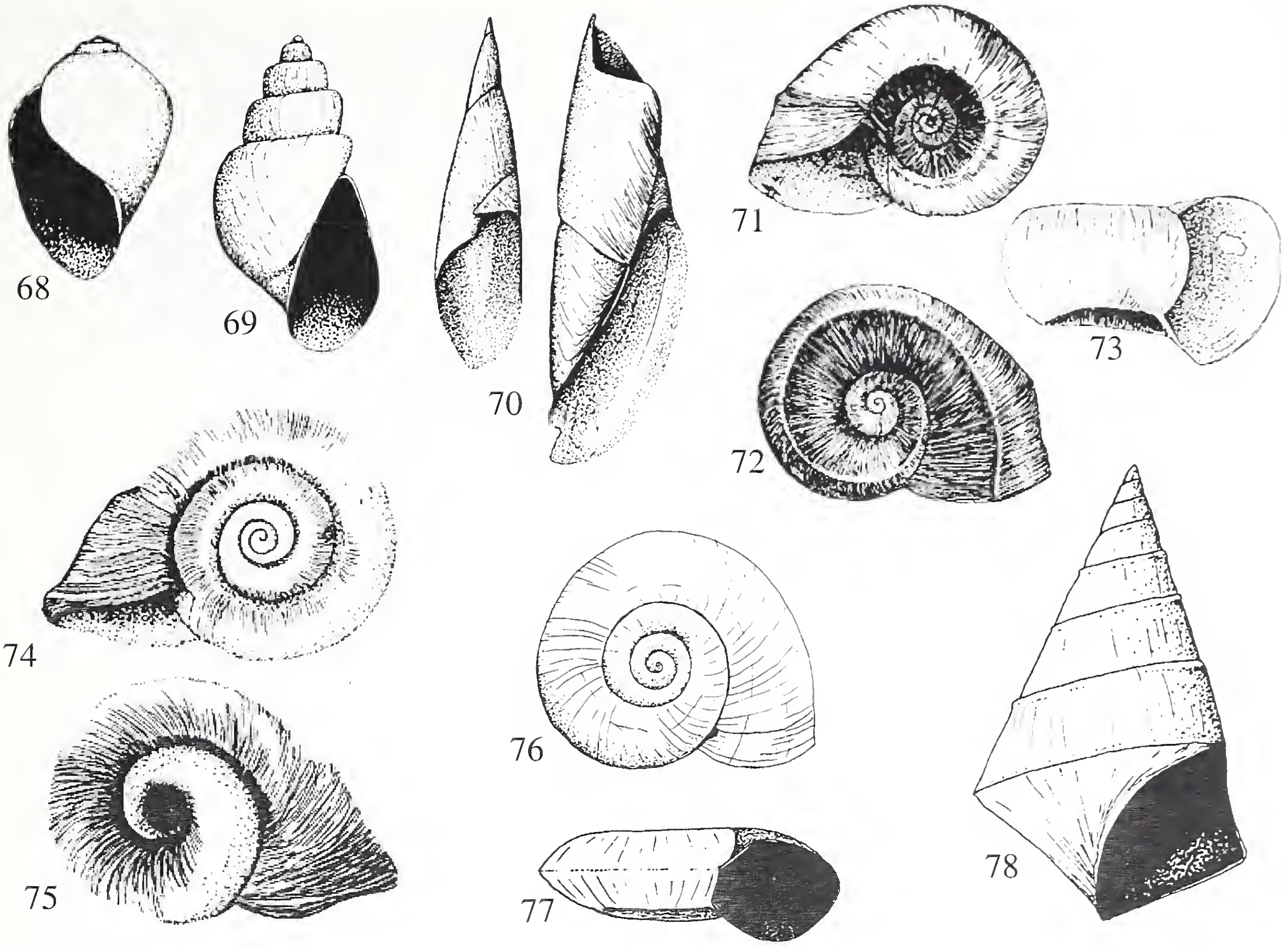
Menyanthes trifoliata: (Fig. 66). *Habitat:* Open, wet areas of neutral fens and mineral-rich *Sphagnum* bogs. *Description:* Achenes (Fig. 66) well preserved, shiny, dark brown to black in color, irregularly shaped, bearing concave depressions. *Stratigraphy:* Beginning in the uppermost portions of fen peats and extending into the early portions of *Sphagnum* peat. *Chronology:* The oldest dated record is 4010 ± 80 ybp (Burket Bog). *Frequency:* 31%. *Abundance:* Infrequent where found.

Order Campanulales
Family Asteraceae

Bidens sp.: (Fig. 67). *Habitat:* Wetlands. *Description:* Achenes (Fig. 67) poorly preserved, light brown in color, elongate-tapering, bearing four bristles. *Stratigraphy:* Fen peat in Little Chapman Bog. *Chronology:* The only dated record is ~1850 ± 80 ybp (Little Chapman Bog). *Frequency:* 6%. *Abundance:* Extremely rare where found.

Kingdom Animalia
Phylum Mollusca
Class Gastropoda
Subclass Pulmonata
Order Basommatophora
Family Physidae

Physa sayii: (Fig. 68). *Habitat:* This species is common to still, shallow waters (0.3–0.8 m) in open areas. It prefers moderate vegetation



Figures 68–78.—68. *Physa sayii* (4 mm); 69. *Lymnaea humilus* (7 mm); 70. *Lymnaea haldemani* fragments (portion of shell showing aperture: 15 mm); 71. *Helisoma anceps*, lateral view, side 1 (15 mm); 72. *H. anceps*, lateral view, side 2; 73. Ventral view of *H. anceps*, showing aperture; 74. *Helisoma campanulata*, lateral view, side 1 (apical) (12 mm); 75. *H. campanulata*, lateral view, side 2; 76. *Gyraulus parvus* apical view (7.5 mm); 77. Ventral view of *G. parvus*, showing aperture; 78. Apical portion of shell of *Pleurocera acuta* (6 mm).

and well-aerated water (Zimmerman 1960). While Zimmerman (1960) reports that *P. sayii* prefers protected areas, Harmen & Berg (1971) found that it was most common in exposed areas. Goodrich & van der Schalie (1944) note that it can sometimes be found on wave battered shores. *Description:* Shell (Fig. 68) well-preserved when found but extremely fragile, sinistral, thin, globose, spire obtuse-conical, body whorl extremely inflated (Harmen & Berg 1971); subfossils lacking periostracum. *Chronology:* The oldest dated record is 11,990 ± 90 ybp (Wilkinson Giant Beaver Locality). *Stratigraphy:* Found throughout the marl stratum in Kiser Lake Fen. In moderate to deep marls in the Wilkinson Giant Beaver Locality. *Frequency:* 13%. *Abundance:* Infrequent to rare where found.

Family Lymnaeidae

Lymnaea humilis: (Fig. 69). *Habitat:* Harmen & Berg (1971) report this species as inhabiting exposed mud flats, where they forage between the gravels with their shells partially exposed to the air. Goodrich & van der Schalie (1944) also report this species as inhabiting mud flats. *Description:* Shell (Fig. 69) well-preserved, up to 15 mm in length but more commonly less than 10 mm, dextral, relatively thick; spire acute-conical, bearing up to 7 whorls, sutures deeply impressed; growth lines inconspicuous, worn; aperture tear-shaped (Harmen & Berg 1971); subfossils lack periostracum. *Stratigraphy:* Marl. *Chronology:* The oldest dated record is 12,070 ± 50 ybp (Aker Mastodont Locality). *Frequency:* 25%. *Abundance:* Infrequent to frequent where found.

Lymnaea haldemani: (Fig. 70). *Habitat:* Common in shallow waters (0.3–1 m) of larger lakes in abundant vegetation. It prefers sheltered bays, and is commonly found on floating vegetation and on the undersides of water-lilies (Zimmerman 1960). It has also been found on rotting *Typha* leaves (Harmen & Berg 1971). This species is always found in limited numbers (Zimmerman 1960). It has not been recorded in Indiana in recent times. *Description:* Shell (Fig. 70) dextral, thin, up to 25 mm; spire extremely acute-conical, elongate; sutures impressed, up to 5 loosely coiled whorls, growth lines inconspicuous (Harmen & Berg 1971); subfossils extremely fragile, lack periostracum. *Stratigraphy:* Marl. *Chronology:* The youngest dated record is 11,240 ± 80 ybp (Wilkinson Giant Beaver Locality), and the oldest dated record is 12,070 ± 50 ybp (Aker Mastodont Locality). *Frequency:* 13%. *Abundance:* Extremely rare to rare where found.

Family Planorbidae

Helisoma anceps: (Figs. 71–73). *Habitat:* Common in shallow waters (<1 m) with abundant vegetation. While Reynolds (1959) reports that it prefers exposed habitats of open lakes, Harmen & Berg (1971) found it most commonly on inorganic substrates in protected areas of ponds as well as quiet pools of small streams. *Description:* Shell (Figs. 71–73) up to 15 mm, planospiral, about 3.5 loosely coiled whorls that are angulated above and below, spire deep, depressed on both sides; sutures shallow; growth lines conspicuous, crowded; aperture broadly lunate, sharply shouldered below and extending beyond plane of spire, inflated and rugose in mature specimens (Harmen & Berg 1971); subfossils well-preserved, but lack periostracum. *Stratigraphy:* Marl. *Chronology:* The oldest dated record is 12,070 ybp (Aker Mastodont Locality). *Frequency:* 19%. *Abundance:* Frequent to abundant where found.

Helisoma campanulata: (Figs. 74, 75). *Habitat:* Occurs in shallow waters of varying substrates in both protected and wave battered areas (Zimmerman 1960). Harmen & Berg (1971) found it mostly on inorganic substrates of small marshy lakes. They rarely found it associated with other *Helisoma* spp., with the exception of *H. anceps* and *H. trivolvis*. Dexter (1950) found the species to be common in *Chara*/*Myriophyllum*, *Nymphaea*/*Pontedaria*, and *Decodon* zones of a basic bog lake in Ohio. *Description:* Shell (Figs. 74, 75) up to 15 mm, sinistral, planospiral, with 4.5 tightly coiled whorls; sutures deep; growth lines conspicuous, evenly spaced, aperture broadly lunate, inflated on mature specimens (Harmen & Berg 1971); subfossils well-preserved, lack periostracum. *Stratigraphy:* Marl. *Chronology:* The oldest dated record is 12,070 ybp (Aker Mastodont Locality). *Frequency:* 19%. *Abundance:* Infrequent where found.

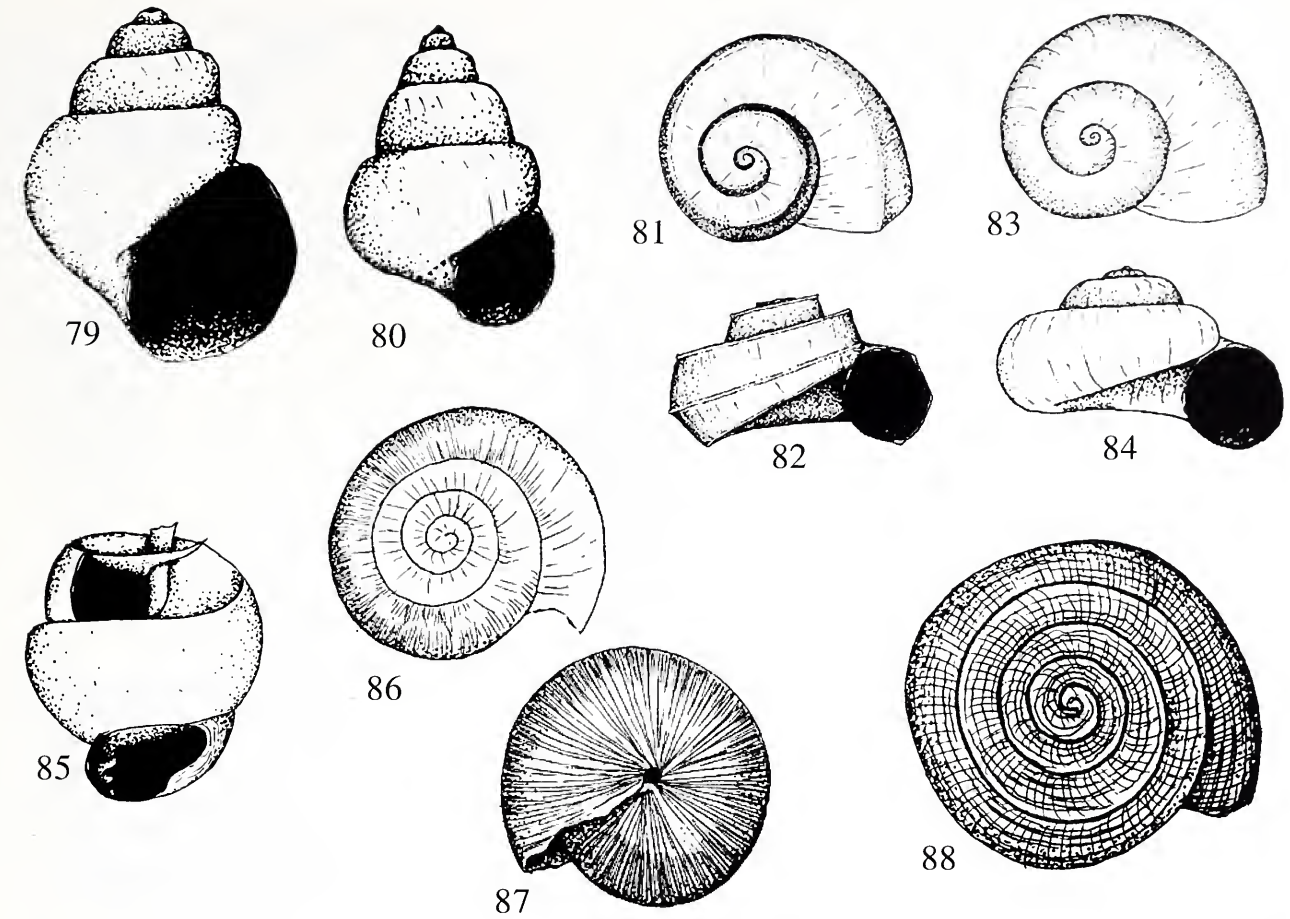
Gyraulus parvus: (Figs. 76, 77). *Habitat:* Occurs in small, shallow, protected waters (Zimmerman 1960), especially in ponds and backwaters with dense aquatic vegetation (Harmen & Berg 1971). Dexter (1950) found it to be restricted to the *Potamogeton* zone. *Description:* Shell (Figs. 76, 77) up to 7 mm, but mostly less than 4 mm, planospiral, 3.5 whorls; spire depressed; sutures deeply impressed; aperture broadly lunate, deflected downward (Harmen & Berg 1971); subfossils well-preserved, lack periostracum. *Stratigraphy:* Marl, rarely in limnic or hemic peat. *Chronology:* The oldest dated record is 12,590 ± 60 ybp (Aker Mastodont Locality). *Frequency:* 31%. *Abundance:* Extremely abundant to abundant where found.

Family Pleuroceridae

Pleurocera acuta: (Fig. 78). *Habitat:* Rivers and unprotected shores of lakes associated with rivers (Harmen & Berg 1971). *Description:* Shell (Fig. 78) dextral, up to 30 mm, thick, elongate and acute-conical, 7–14 whorls, apical whorls bearing 1–3 carinae; body whorl shouldered at outer periphery, striate below; aperture angulate, lacrimate, canaliculate (Harmen & Berg 1971); growth lines inconspicuous; subfossils usually fragmented, lack periostracum. *Stratigraphy:* Marl. *Frequency:* 6%. *Abundance:* Rare where found.

Family Hydrobiidae

Amnicola limosa: (Fig. 79). *Habitat:* Common in protected areas of shallow lakes and muddy bays in 0–3 m of water (Zimmerman 1960). It is also found in marshes, ponds, temporary stream pools, creeks and rivers (Harmen & Berg 1971). Reynolds (1959) reports that it has been found in brackish water as well as freshwater and prefers sandy sub-



Figures 79–88.—79. *Amnicola limosa* (5 mm); 80. *Amnicola lustrica* (3.5 mm); 81. *Valvata tricarinata*, apical view (4 mm); 82. Ventral view of *V. tricarinata*, showing aperture; 83. *Valvata sincera*, lateral view (4 mm); 84. Ventral view of *V. sincera*, showing aperture; 85. *Gastrocopta* sp. shell fragment (1.5 mm); 86. *Retinella* sp., apical view (2.5 mm); 87. *Retinella* sp., ventral view; 88. *Helicodiscus parallelus* (3.5 mm).

strates with dense beds of *Chara*, *Potamogeton*, *Vallisneria*, and *Elodea*. Dexter (1950) reports it from the *Chara*/*Myriophyllum*, *Nymphaea*/*Pontedaria*, and *Decodon* zones. Zimmerman (1960) states the most important limiting factor for this species is vegetation (preferably abundant) and protection from exposure. He also reports that this species can endure long periods of emergence as long as it remains moist, but unusually high water temperatures can rapidly exterminate it from a waterbody. *Description:* Shell (Fig. 79) up to 5 mm, dextral; spire slightly elevated; apex truncated; sutures deep; whorls rounded, inflated, up to 4.5 in number; aperture broadly lacrimate (Harmen & Berg 1971); growth lines inconspicuous; subfossils well-preserved, lack periostracum. *Stratigraphy:* Marl. *Chronology:* The oldest dated record is 12,590 ± 60 ybp (Aker Mastodont Locality). *Frequency:* 19%. *Abundance:* Extremely abundant to abundant where found.

Amnicola lustrica: (Fig. 80). *Habitat:* This species is less common than *A. limosa*, although it occupies similar habitats (Harmen & Berg 1971). It prefers shallow (0–2 m), highly vegetated waters, where it often inhabits filamentous algae (Zimmerman 1960). *Description:* Shell (Fig. 80) dextral, elevated, acute-conical; sutures deep; aperture lacrimate (Harmen & Berg 1971); growth lines inconspicuous; subfossils well-preserved, lack periostracum. *Stratigraphy:* Marl. *Chronology:* The oldest dated record is 12,590 ± 60 ybp (Aker Mastodont Locality). *Frequency:* 25%. *Abundance:* Frequent to infrequent where found.

Family Valvatidae

Valvata tricarinata: (Figs. 81, 82). *Habitat:* Inhabits a wide variety of conditions but is most common in lakes. Harmen & Berg (1971) report that most specimens from lotic conditions are depauperate. Dexter (1950) found it to be common in the *Chara/Myriophyllum*, *Potamogeton*, *Nymphaea/Pontedaria*, and *Decodon* zones. Reynolds (1959) reports that the species is partial to firm bottoms and is usually associated with *Oedogonium*, *Cladophora*, and *Vaucheria*. *Description:* Shell (Figs. 81, 82) dextral, up to 5 mm, turreted; sutures deep; spire low; whorls 4, angulate, top, middle and bottom, each bearing a carina; aperture circular (Harmen & Berg 1971); growth lines somewhat conspicuous; subfossils well-preserved, lack periostracum. *Stratigraphy:* Marl. *Chronology:* The oldest dated record is 12,590 ybp (Aker Mastodont Locality). *Frequency:* 25%. *Abundance:* Extremely abundant where found.

Valvata sincera: (Figs. 83, 84). *Habitat:* This species is reported as being primarily from deep water (5– 6 m), usually below 3 m in depth, of cold lakes with limited vegetation (Zimmerman 1960). Harmen & Berg (1971) found it at a depth of 5 m. *Description:* Shell (Figs. 83, 84) dextral, up to 4 mm, turreted; sutures deep; spire low; whorls 2.5, circular, acarinate; aperture circular (Harmen & Berg 1971); growth lines somewhat conspicuous to inconspicuous; subfossils well-preserved, lack periostracum. *Stratigraphy:* Marl. *Chronology:* The oldest dated record is 15,910 ± 90 ybp (Celery Bog). *Frequency:* 25%. *Abundance:* Infrequent to rare where found.

Order Ophistobranchia
Suborder Stylommatophora
Family Pupillidae

Gastrocopta sp.: (Fig. 85). *Habitat:* Terrestrial. *Description:* Shell (Fig. 85) ovate, smooth, aperture bearing large, blunt teeth; subfossil shells fragile. *Stratigraphy:* A few shells were found in the earliest sediments of the peat stratum of Kiser Lake Fen. *Chronology:* The oldest dated record is 4360 ± 100 ybp (Kiser Lake Fen). *Frequency:* 6%. *Abundance:* Infrequent to rare.

Family Zonitidae

Retinella sp.: (Figs. 86, 87). *Habitat:* Terrestrial. *Description:* Shell (Figs. 86, 87) thin, smooth, lustrous, depressed with four to six whorls, well-preserved. *Stratigraphy:* A few specimens in sandy marl of Kiser Lake Fen. *Chronology:* The oldest dated record is 4360 ± 100 ybp (Kiser Lake Fen). *Frequency:* 6%. *Abundance:* Rare.

Family Endodontidae

Helicodiscus parallelus: (Fig. 88). *Habitat:* Terrestrial. Goodrich & van der Schalie (1944) report this species as being most common to flood plains. *Description:* Shell (Fig. 88) disc-shaped, bearing parallel, raised, lines; spire flat; umbilicus broad, shallow. *Stratigraphy:* One specimen from the uppermost marl stratum of the Wilkinson Giant Beaver Locality, Whitley County, Indiana. *Chronology:* The oldest dated record is 11,240 ± 80 ybp (Wilkinson Giant Beaver Locality). *Frequency:* 6%. *Abundance:* Extremely rare.

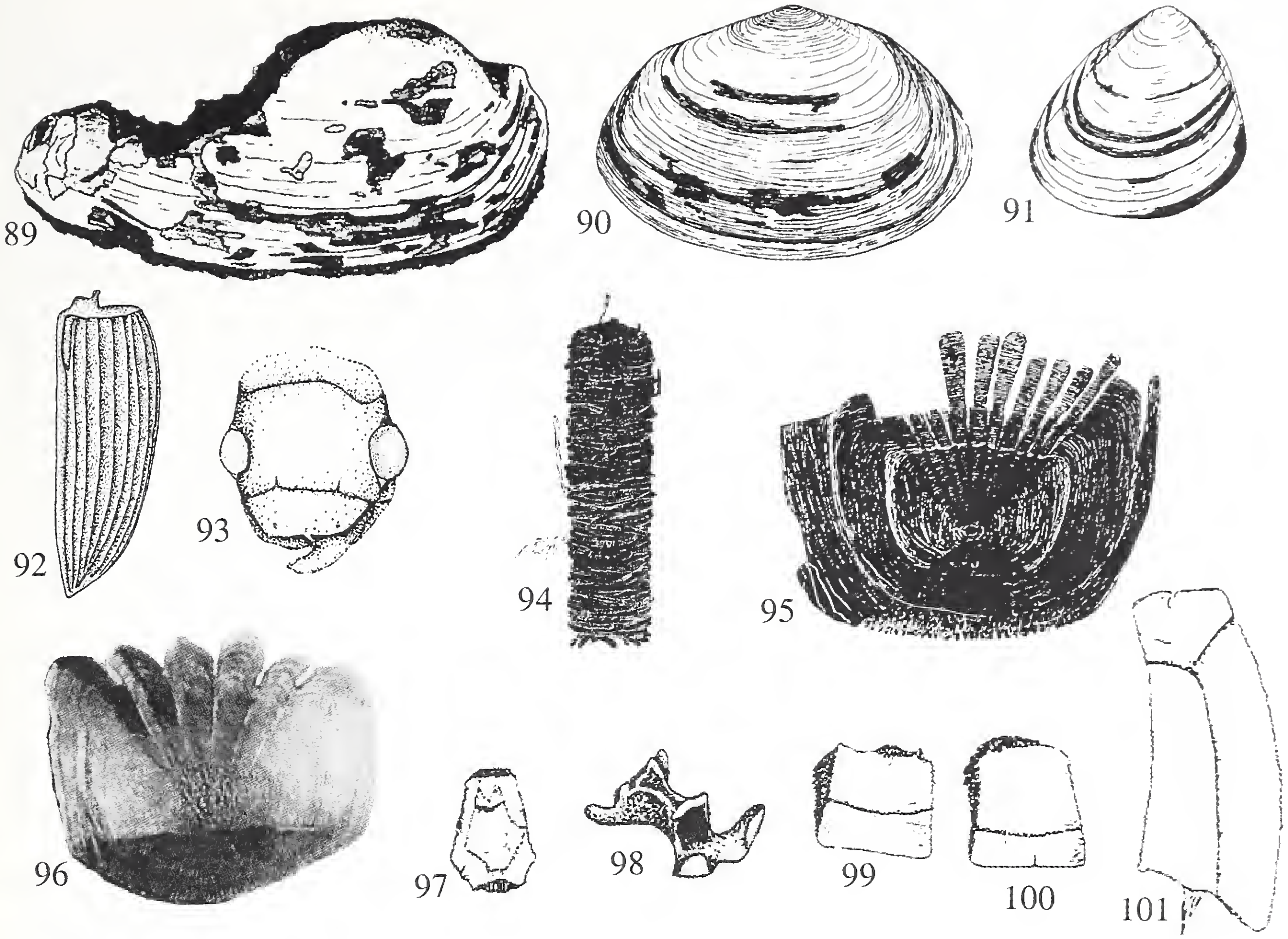
Class Bivalvia
Order Prionodesmacea
Family Unionidae

cf. *Elliptio dilatata*: (Fig. 89). *Habitat:* Lakes, ponds, and limnic waters with fish communities. *Description:* Valves (Fig. 89) very poorly preserved, powdery and brittle, periostracum present. *Stratigraphy:* Marl. *Chronology:* The oldest dated record is 11,240 ± 80 ybp (Wilkinson Giant Beaver Locality). *Frequency:* 6%. *Abundance:* Extremely rare.

Order Teleodesmacea
Family Sphaeriidae

Sphaerium sp.: (Fig. 90). *Habitat:* Lakes, ponds, marshes, swamps, sloughs, slow rivers and streams. *Description:* Valves (Fig. 90) up to 20 mm, nearly equal in morphology, symmetrical, nearly as long as broad, relatively thin; surface bearing eccentric ridges; subfossils moderately to poorly preserved, larger shells usually broken, surface often has remnants of periostracum. *Stratigraphy:* Marl. *Chronology:* The oldest dated record is 11,990 ± 90 ybp (Wilkinson Giant Beaver Locality). *Frequency:* 13%. *Abundance:* Abundant to frequent where found.

Pisidium sp.: (Fig. 91). *Habitat:* Lakes, ponds, marshes, swamps, sloughs, slow rivers and streams. *Description:* Valves (Fig. 91) up to 6 mm but usually 3–4 mm, laterally assymetrical; surface more or less smooth but eccentric growth rings visible; subfossils well-preserved, bearing remnants of the periostracum. *Stratigraphy:* Marl, rarely in limnic or sapric sediments. *Chronology:* The oldest dated record is 12,590 ybp (Aker Mastodont Locality). *Frequency:* 38%. *Abundance:* Extremely abundant to rare where found.



Figures 89–101.—89. *Elliptio dilatata* (100 mm); 90. *Sphaerium* sp. (12 mm); 91. *Pisidium* sp. (5 mm); 92. Coleoptera elytron (6 mm); 93. Coleoptera head capsule (2 mm); 94. Larval case of cf. *Micrasema* sp. (Trichoptera) (20 mm); 95. *Lepomis* cf. *macrochirus* scale (5 mm); 96. *Perca flavescens* scale (4 mm); 97. *Sternotherus odoratus* cranial bone (9 mm); 98. Vertebra of *S. odoratus* (7 mm). 99. Peripheral plate of *S. odoratus* (9 mm). 100. Peripheral plate of *S. odoratus* (10 mm); 101. Costal plate of *S. odoratus* (31 mm).

Phylum Arthropoda
Class Insecta
Order Coleoptera

Unidentified appendages: (Figs. 92–93). *Habitat:* Mostly terrestrial. *Stratigraphy:* Restricted mostly to peat strata. *Frequency:* 63%. *Abundance:* Abundant.

Order Trichoptera
Family Brachycentridae

cf. *Micrasema* sp.: (Fig. 94). *Habitat:* Weed-choked, lotic environments. *Description:* Case (Fig. 94) more or less cylindrical, open at both ends, constructed from *Ceratophyllum demersum* stems. *Stratigraphy:* A single specimen from basal aquatic sediments of Svoboda Fen. *Frequency:* 6%. *Abundance:* Extremely rare.

Phylum Chordata
Class Osteichthyes
Family Centrarchidae

Lepomis cf. *macrochirus*: (Fig. 95). *Habitat:* All of the sunfish species prefer relatively warm waters generally found in mesotrophic to eutrophic waters of lakes and ponds; also found in lotic waters. The natural range of the family is from southern Canada to the Gulf of Mexico (Page & Burr 1991). *Description:* Scales (Fig. 95) ctenoid, subquadrate with 8–15 primary anterior radii that converge at the focus; radii crenate at scale margin; anterolateral corners square, postero-lateral corners rounded; focus located in posterior half of scale (Daniels 1996). *Stratigraphy:* Limnic sediments and marls of Kiser Lake Fen, Little Chapman Bog, and Little Arethusa Bog.

Chronology: The oldest dated record is >4360 ybp (Kiser Lake Fen). *Frequency:* 19%. *Abundance:* Infrequent where found. Appear sporadically throughout limnic sediments.

Family Percidae

Perca flavescens: (Fig. 96). *Habitat:* Freshwater lakes, ponds, and quiet areas of streams and rivers in the Atlantic, Arctic, Great Lakes, and Mississippi River Basins (Page & Burr 1991). *Description:* Scales (Fig. 96) ctenoid, with 4–8 primary radii in anterior field only; radii deeply cleft at scale margin; focus located on posterior third of scale (Daniels 1996). *Stratigraphy:* Limnic sediments of Celery Bog. *Chronology:* The oldest dated record is >9530 ± 90 ybp (Celery Bog). *Frequency:* 6%. *Abundance:* Somewhat frequent where found.

Class Reptilia
Order Chelonia
Family Kinosternidae

Sternotherus odoratus: (Figs. 97–101). *Habitat:* Rivers, lakes, ponds, marshes, swamps, and sloughs. Prefers slow current and soft organic bottom or marl (J.A. Holman pers. comm.). *Stratigraphy:* Five bones (Figs. 97–101), presumably of a single animal, were found in the limnic sediment of Little Chapman Bog, Koscisuko County. *Chronology:* The only dated record is 3680 ± 80 ybp (Little Chapman Bog) (Swinehart & Holman 1999). *Frequency:* 6%. *Abundance:* Extremely rare.

CONCLUSIONS

Although not exhaustive, the present paper characterizes the macroscopic subfossil taxa common to wetland deposits in northern Indiana, and should provide useful information to other investigators working on the palaeoecology of wetlands in the southern Great Lakes region. Macrofossil surveys are a necessary complement to pollen data, especially when reconstructing local ecosystems. For example, although many pollen profiles show *Picea* as being abundant to within 8000 ybp, no macrofossils of *Picea* less than about 11,000 ybp have been recovered in Indiana. This suggests that macrofossil data may be more accurate for local or even regional reconstructions. Radiocarbon dating of macroscopic subfossils has indicated that many of the taxa which are common to temperate, eutrophic waters colonized aquatic environments as early as the late-Pleistocene, suggesting that conditions may have become favorable to these species earlier than previously thought.

Although the percent frequency determined for each taxon (based on 16 sites) is helpful, it is biased by the site selection methods. Most of the sites are peatland deposits that attracted the author because of their unique, boreal flora. Other sites were studied because of the discovery of ice-age mammal remains. Further investigations of different wetland types, such as emergent marshes and extant lakes, would add to the understanding of late-glacial and post-glacial biogeography. Additional radiocarbon dates will help further document the dates and rates of the colonization of various taxa after glacial retreat. Furthermore, use of scanning electron microscopy in the examination of small, obscure seeds is recommended. This will greatly increase the number of identifiable taxa.

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DETECTION EFFICIENCY OF GAMMA RAYS THROUGH FATTY TISSUE FOR THE EXTERNAL DETECTION OF SENTINEL LYMPH NODES IN BREAST CANCER DIAGNOSIS

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ABSTRACT. The ability to detect gamma ray passage through fatty tissue has biomedical applications in the diagnosis of metastatic breast cancer. The uptake of a ^{99m}Tc-labeled sulfur colloid solution into the primary or sentinel lymph nodes (SLN) supplying the breast is one mechanism by which potential metastasis is being assessed. If γ-rays from the decaying ^{99m}Tc could be measured externally, the invasiveness of this diagnostic procedure would be greatly reduced. Using a ^{57}Co source, this experiment assessed γ-ray intensity attenuation through porcine fatty tissue for thickness up to 76 mm. The porcine tissue accounted for a significant attenuation of intensity, but further significant losses were seen due to the increase in distance between the detector and the ^{57}Co source. It was found that porcine fatty tissue has γ-ray attenuation properties nearly identical to that of breast tissue. From the porcine tissue study and subsequent observation of three SLN biopsy procedures, it was found that detecting SLN's via external γ-ray detection is not self-sufficient. The use of a blue dye as an adjunct diagnostic tool is also necessary for the high success rate desired. While an external γ-ray detection method will not replace the traditional SLN biopsy procedure, it may serve as a pre-operative tool to limit the invasiveness of the procedure.

Keywords: Gamma-ray, breast cancer, sentinel lymph node, radiation detection

Breast cancer is the second leading cause of cancer related deaths in the U.S. among women (Ries et al. 2002). Because of breast cancer's high incidence and mortality rate, intense efforts have been made to enable early diagnosis and treatment. Traditionally, diagnostic tools were limited; and treatments such as radical mastectomies were rather extreme. The patient would not only lose the breast, the pectoralis muscles and axillary lymph nodes; but lymphedema, wound infection, pain, neurological deficits, and weakness were often associated with the invasiveness of the radical procedure (Cox et al. 1998). More recently, the use of sentinel lymph node (SLN) biopsies has become widely accepted in the diagnosis of metastatic breast cancer, due to the less invasive nature of the procedure (Burak et al. 2002). The technique is used to determine the lymphatic flow around tumors and to the regional lymph nodes, but is less invasive than more traditional methods resulting in less trauma to the patient. The determination of lymphatic flow from a tumor is done by assessment of the lymph nodes. Each tumor may have from 1–7 primary, or sentinel, lymph nodes that receive circulating lymph from the tumor. Thus immunohistological assessment of the SLN for metastatic tumor cells will determine if metastasis has occurred. A tumor that is supplied by peri-tumor lymph vessels is more likely to have metastasis occur as the lymphatic system is the primary route for metastasis. (Albertini et al. 1996)

The SLN biopsy involves two distinct procedures. The first is an injection of a sulfur-colloid solution radio-labeled with ^{99m}Tc, a radioisotope with a half-life of 6 h which emits 142.7 KeV γ-rays (Firestone 1996). It is important that the gamma rays emitted are low energy as the procedure is diagnostic and the tissue should not be damaged from the radiation exposure. The ^{99m}Tc-labeled sulfur colloid solution is injected around the tumor (or peri-nipple if the tumor is near the axillary basin) about 1–6 h prior to the procedure. Some time between the injection and operative procedure a lymphoscintography, which detects gamma rays externally, is performed. The lymphoscintography is done with a gamma camera, which indicates to the physician the possible location of radioactive SLN's prior to the operative procedure. If a route for metastasis from the tumor to a primary lymph node exists, ^{99m}Tc will collect in the SLN (Noguchi 2002).

In addition to the ^{99m}Tc injection, the injection of an isosulfan blue dye circumferentially around the tumor is done just prior to the intra-operative procedure. While the ^{99m}Tc method is necessary for accurately identifying the SLN's, it is not sufficient as a diagnostic tool. The use of the blue dye is an alternative means by which SLN(s) may be visually located, leading to increased success rates in diagnosing potential metastasis (Noguchi 2002). The blue dye method acts much like the ^{99m}Tc, by enabling a visual determination of the lymph vessels and any nodes that supply the tumor region. Cox et al. (1998b) demonstrated the need for both methods in their biopsy of the 844 SLN's they harvested, in which 40.2% were positive for ^{99m}Tc only, 32.2% were blue only, and 27.6% were both positive and blue. In another study Cox et al. (1998a) also found results comparable to those above.

The intra-operative procedure employs a gamma detector, several of which are on the market (e.g., the Navigator, US Surgical Corporation, Norwalk, Connecticut, and the Neoprobe, Neoprobe Corp., Dublin, Ohio). The surgeon initially probes externally with the gamma probe confirming potential spots of positive radiation seen on the films from the gamma camera. The surgeon will then incise along the axillary basin accessing potential nodes of interest. In some cases, the surgeon may excise the tumor to remove some of the background noise that can interfere with the sensitivity of the gamma detector. The surgeon will remove any blue staining or radioactive lymph nodes and immunohistological testing will occur to assess for presence of metastasis (Noguchi 2002).

Compared to total axillary lymph node dissection and radical mastectomies, the SLN biopsy has been successful in removing much of the trauma and many of the complications for the patient. There are still some complications, though, that warrant further refinement of the SLN biopsy procedure. The risk for infection, potential for lymphedema, and tissue trauma, as well as the cost due to time and facilities still leaves potential room for improvement (Cox et al. 1998a). Additionally, the SLN biopsy presents no new information for some patients. While a radioactive or blue-dyed SLN is found in most patients, 5–8% will not present with a SLN. Of those patients in which no SLN was found, 1–15% did present with metastasis (Cox et al. 1998a; Cox et al. 1998b; Albertini et al. 1996).

The purpose of this experiment was to investigate the possibility of external detection of ^{99m}Tc radioactivity, thus eliminating any unnecessary invasiveness of the procedure. First, the detection of gamma rays through sample tissue (porcine fat) was assessed to ensure that the fatty tissue is analogous to that of human breast tissue. Secondly, the ability to detect gamma rays with both increasing tissue thickness and increasing distance from the ^{57}Co source was assessed. The γ-ray intensity was assessed at distances up to 76 mm of tissue.

METHODS

Two trials were conducted for this experiment. The first trial was done to ensure that the tissue used in the experiment was representative of human breast tissue. The second trial measured not only the attenuation of gamma rays through determined breast tissue thickness (as in trial one), but also took into consideration the change in distance between the source of radiation and the detector, since radiation intensity decreases with increasing distance from the source (Knoll 1989). Both trials were run using a ^{57}Co (1 μCurie) source and a three inch by three inch (76.2 mm by 76.2 mm) NaI detector. ^{57}Co was used in this study since its primary γ-ray emission has an energy of 122.1 KeV (Firestone 1996), similar to that of ^{99m}Tc, 142.7 KeV (Fig. 1), thus giving it similar attenuation properties – to within 5% – when passing through matter (ICRU 1989). The tissue used in each trial was freshly removed from the lumbar region of a pig. The slabs of fat/tissue were sliced into 2–4 mm thick pieces and large enough to cover the entire face of the detector. The ^{57}Co source was attached to the bottom of a plastic container, into which increasing layers of fatty tissue were added. For each trial a baseline intensity reading was made through the plastic container, corresponding to zero thickness of tissue. Subsequent intensity readings were taken with increasing thickness of tissue (1–4 mm). Each measurement was taken over a 10

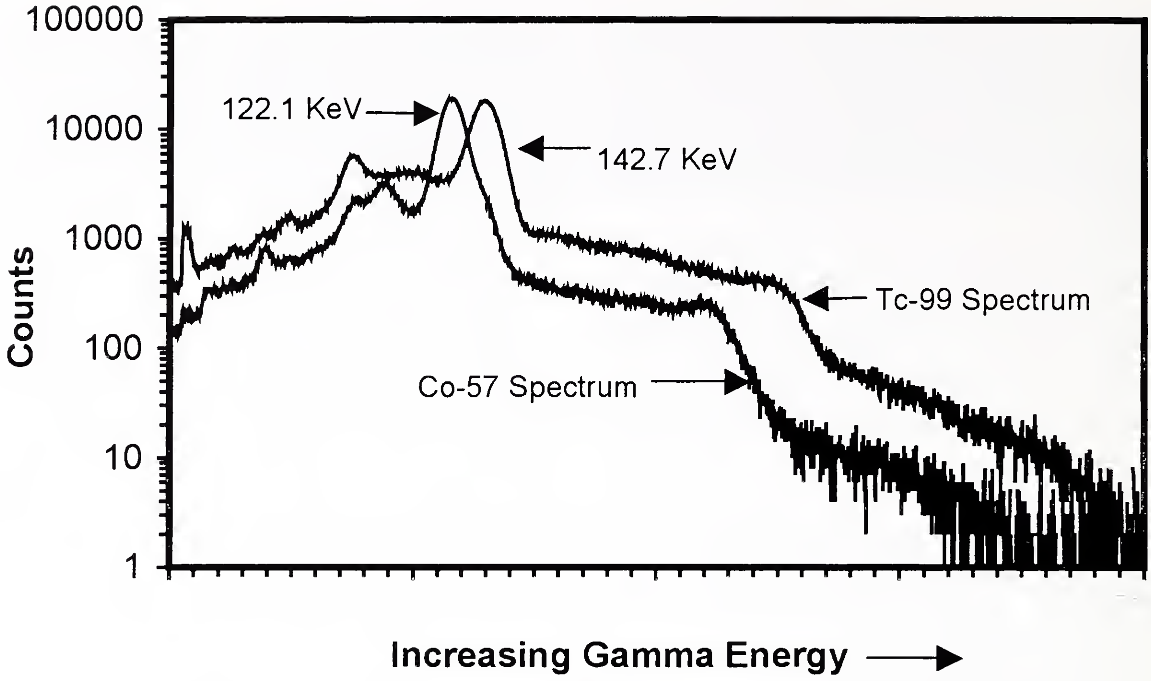

Figure 1.—Gamma ray spectrum for ^{57}Co and ^{99m}Tc. Shown are the characteristic 122.1 and 142.7 KeV gamma ray peaks for ^{57}Co and ^{99m}Tc, respectively. The 122.1 KeV gamma ray from ^{57}Co was used as a substitute for ^{99m}Tc to measure the attenuation properties of porcine tissue. The number of counts in the 122.1 KeV peak was monitored as a function of increasing tissue thickness.

min period during which gamma rays detected were recorded with an Ortec Trump Multichannel Analyzer (Fig. 2). The γ-ray intensity was determined by integrating counts under the 122.1 KeV γ-ray peak.

Trial 1.—In Trial 1, the gamma ray detector was fixed at 82 mm from the plastic container with the ^{57}Co source attached to the bottom of the container. A baseline reading was taken, corresponding to zero tissue thickness, followed by sequential additions of tissue slices with measured thickness. The stack of tissue was periodically measured to ensure that actual thickness present was the sum total of individual slices used.

Trial 2.—In Trial 2, the procedure and set up was the same as Trial 1, except for the positioning of the γ-ray detector. The detector was not fixed, but placed directly upon the tissue, as would be the case in a surgical procedure. As additional thickness of porcine tissue was added, the detector's position relative to the source changed, as it would with increasing thickness of breast tissue during a SLN biopsy procedure.

RESULTS

The attenuation of γ-rays through solid materials is well known through the relation, $I = I_o e^{-e(\mu/e)x}$, where I is the intensity of γ-radiation passing through a thickness, *x*, of material. I_o is the incident (baseline) radiation of

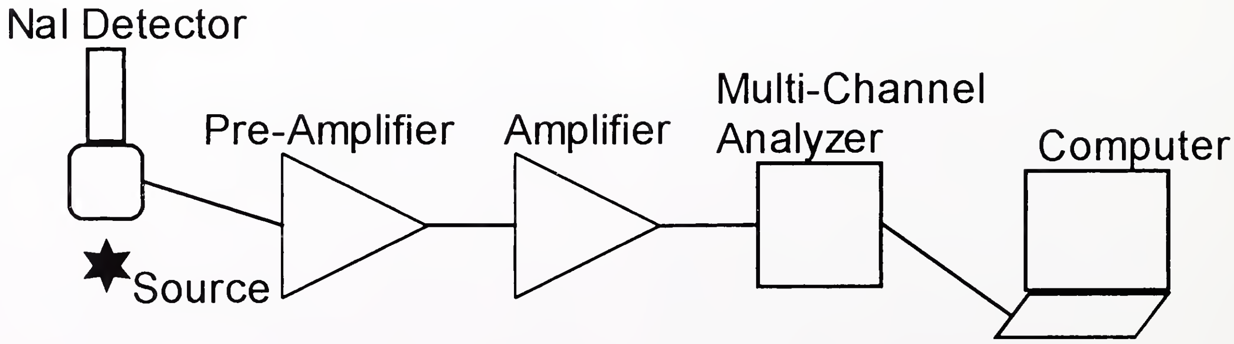

Figure 2.—Electronics diagram for the detection of ^{57}Co γ-rays. Once detected in the NaI crystal, the gamma ray signals are amplified and sent to a multi-channel analyzer which sorts the signals by energy and histograms them for analysis by computer.

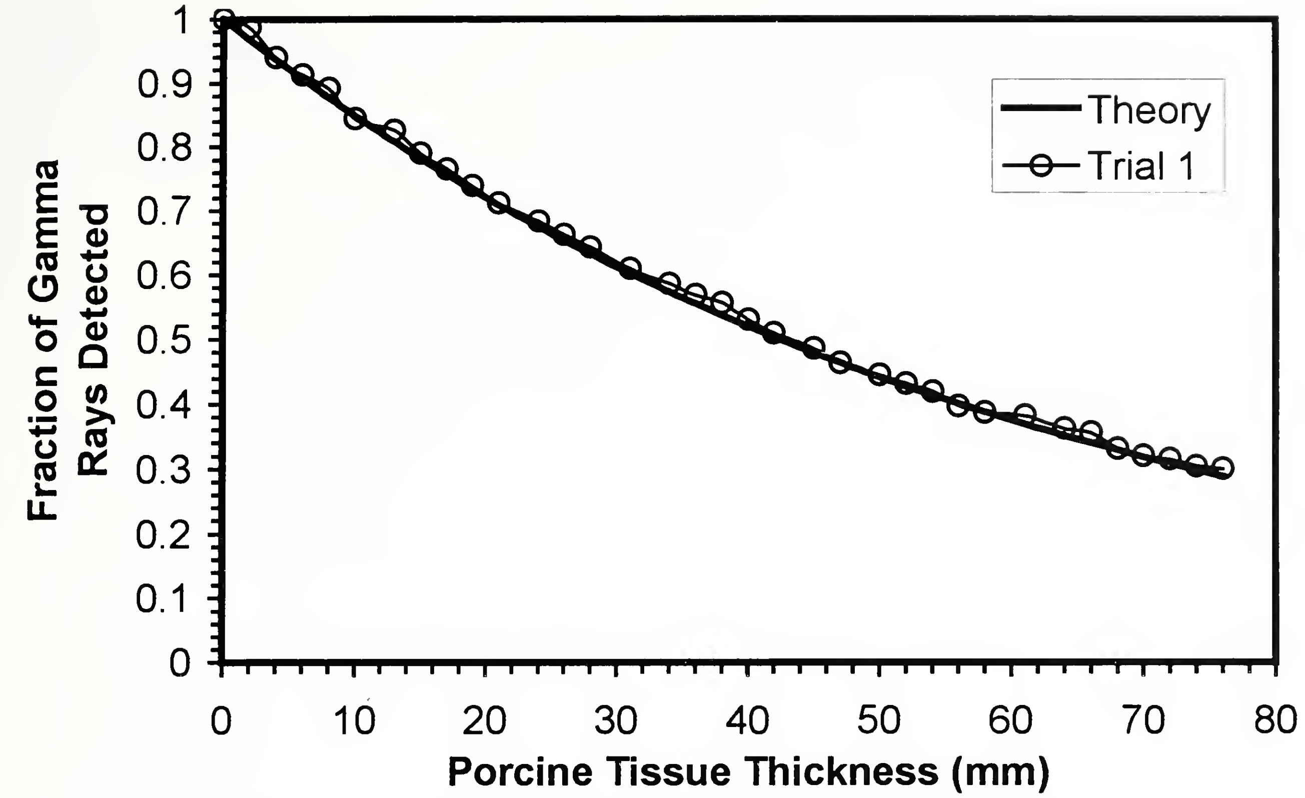

Figure 3.—^{57}Co (122 KeV) gamma ray attenuation as a function of porcine tissue thickness at a fixed detector distance. Trial 1 data exhibits the exponential decay in gamma intensity as expected from theoretical calculations.

the source (Friedlander 1981). The coefficients μ and ρ are the attenuation coefficients and density of the material studied. For breast tissue, the density is known to have a value of 1.02 g/cm^3 and μ/ρ is 0.1602 cm^2/g (ICRU 1989). Since ρ and μ are known for breast tissue, the expected intensities for increasing thickness could be predicted. Figure 3 shows the data and predicted intensities normalized to a value of 1.0. From the data, it was concluded the porcine tissue used to model breast tissue was representative of the attenuation properties of breast tissue.

The results of Trial 2 are presented in the same fashion as in Trial 1 and are plotted in Fig. 4. The loss of intensity does not exhibit the same behavior as that in Trial 1. The additional loss of intensity observed is due to the change in distance between the ^{57}Co source and the detector. As expected, the loss of intensity indicates that the greater the separation, the greater the loss of intensity due to geometrical considerations (Knoll 1989). At a distance of 25 mm from the detector, an additional 18% loss in intensity is observed (relative to a fixed detector measurement) and increasing intensity losses were recorded for increasing tissue thickness.

DISCUSSION

It was found that porcine fatty tissue is representative of human breast tissue. At 26 mm breast tissue attenuates 122.1 KeV γ-rays 34.6%, while porcine tissue had a γ-ray intensity attenuation of 33.8%. This has implications in future studies assessing passage of γ-rays through breast tissue, since porcine fatty tissue may substitute for human breast tissue. There are obvious cost and ethical issues that can be avoided with use of porcine tissue versus human tissue.

Secondly, many factors affect the attenuation of γ-ray intensity and efficiency of detection when measuring γ-rays in SLN biopsies. Source half-life, tissue attenuation, geometry, distance, detector efficiency, and infiltration of ^{99m}Tc into the lymphatic system all play a significant role in limiting the efficiency of detecting γ-rays.

Since the ^{57}Co source used in this study has a half-life of 271 days (Firestone 1996), no appreciable loss of intensity due to decay oc-

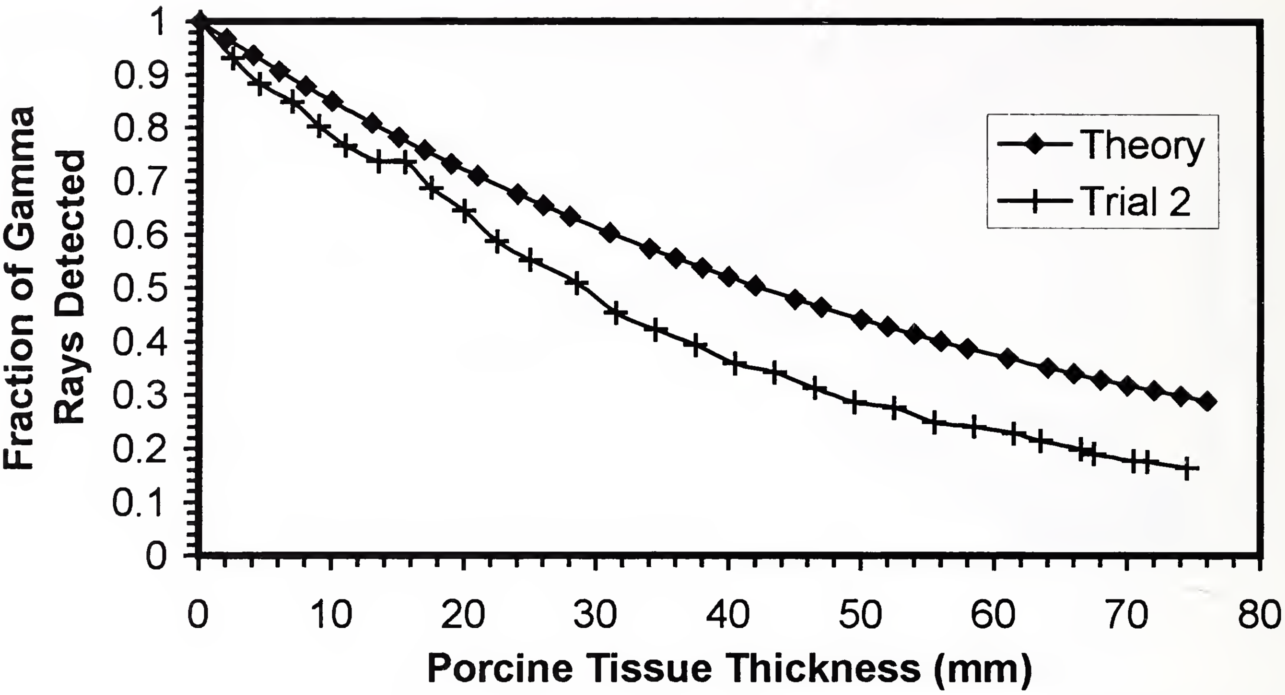

Figure 4.—^{57}Co (122 KeV) gamma ray attenuation as a function of porcine tissue thickness with increasing detector distance. Trial 2 data exhibits an additional decrease in gamma ray intensity (relative to Trial 1) due to increasing source-to-detector distance.

curred during the course of the experimentation. In contrast, the ^{99m}Tc source used in SLN biopsies has a half-life of only 6 h. Therefore a significant loss of intensity will be seen over a several hour period, which could become a significant problem if detection were to occur beyond a certain time period. It is important to note the source strength may differ in different protocols. Radioactive doses ranging from 0.2 mCi to 1.0 mCi have been used in SLN studies (Noguchi 2002).

Geometric factors also play a role in γ-ray intensity measurement. Radioactive sources emit γ-rays isotropically and not in a preferential direction. Due to the detector's location on one side of the source and the isotropic γ-ray emission, there is at least a 50% loss in measurable intensity. Further decreases in intensity are seen as the distance is increased between the source and detector. The detector used in this experiment demonstrated an additional 18% loss in intensity over and above the expected attenuation due to tissue alone at 25 mm from the source. The detector used in this study is relatively large, providing for increased surface area for detection. The actual SLN biopsy procedure utilizes a much smaller probe of 14–19 mm in diameter, greatly reducing the number of incident γ-rays that can be detected.

In addition to the loss of intensity due to geometry, there is also a decrease in the recorded intensity of γ-rays due to intrinsic efficiency of the detector. It is known that NaI detectors have a detection efficiency of 10%, as it takes an average of 10 γ-rays to produce one recorded event (Friedlander 1981). This detector efficiency provides for a significant loss of detectable events. Further loss is seen by the intercalation of the ^{99m}Tc-sulfur colloid within the breast tissue and lymphatic system. It has been consistently shown that only 1–5% of the ^{99m}Tc-sulfur colloid actually reaches any given SLN (Cox et al. 1998a; Reintgen et al. 2000). Since only a small amount of radioactivity reaches a SLN, external detection becomes difficult.

To demonstrate the effects of the above-mentioned factors on the external detection of γ-rays for breast cancer diagnosis, assume a 1 mCi injection of ^{99m}Tc is administered to the patient. Table 1 illustrates the resulting γ-ray intensity in the detector assuming an operative procedure 6 h following the injection at a detector distance of 25 mm. As evident in Table 1, a small amount of gamma radiation is detectable during a SLN procedure if detection is attempted externally—illustrating the need for an internal operative procedure to get as close to the SLN's as possible.

Table 1.—Resulting γ-ray intensity in detector due to various detection factors, assuming an initial injection of 1 mCi in patient.

Initial dose	Detection factor	Reduction factor
1 mCi*	Tissue attenuation for 25 mm of tissue	0.67
	Half-life of ^{99m}Tc (6 hours)	0.50
	Geometric efficiency	0.50
	Detector to source 25 mm	0.82
	Infiltration to SLN	0.01
	Resulting γ-ray intensity in detector =	0.0014 mCi

Our observations of three SLN procedures (T. Goedde pers. comm.) made evident additional problems for external detection of the gamma radiation of interest. As the ^{99m}Tc-sulfur colloid intercalates through the breast, a high radioactivity area remains near the injection site. Gamma rays originating from this high-activity area provide for subsequent background noise that is detected as real, recorded γ-rays, but not indicative of SLN's. Since low γ-ray levels are present in a SLN, as demonstrated above, this higher level noise can mask γ-radiation from a SLN of interest. Subsequently, uniquely identifying a SLN in the midst of background noise becomes difficult when attempted externally.

As has been shown, external γ-ray intensity measurement becomes increasingly difficult due to a variety of factors. Controlling the time-dependent variation in the activity levels is generally accomplished by performing the procedure 2–6 h following the injection; decreasing this interval will allow for increased intensity values. Since much of the detection difficulty is due to proximity of the detector to the source, it is necessary to perform the procedure from an internal *versus* external perspective to get the detector as close to the source as possible. The operative approach has additional justification as well.

The incorporation of an isosulfan blue dye is done concurrently to assess lymph vessels and SLN's. The fact that not all SLN's demonstrate radioactivity has been shown in multiple studies. Cox et al. (1998a) found that 30% of the 1348 SLN's were found visually with use of the blue dye and not radioactive. In a separate study, Cox et al. (1998b) found 4.6% of 844 SLN's were not radioactive, but presented with blue dye.

ACKNOWLEDGMENTS

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THE FLORA AND VEGETATIONAL COMMUNITIES OF WILBUR WRIGHT FISH AND WILDLIFE AREA, HENRY COUNTY, INDIANA

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ABSTRACT. This paper on Wilbur Wright Fish and Wildlife Area (WWFWA), Henry County, Indiana, documents 635 vascular plant species and varieties within the 416.6 ha (1029 acre) site. The 635 species and varieties represent 343 genera and 109 families with the Asteraceae (76 species), Cyperaceae (55 species including 44 *Carex* spp.) and Poaceae (53 species) having the highest number of species. Unusual sedges include *Carex atherodes* and *Carex gravida*. A total of 274 species is recorded for the first time from Henry County. Of the 611 angiosperms listed, 163, or approximately 27%, are non-native or exotic species. The vascular flora of WWFWA includes one rare species (*Rudbeckia fulgida* var. *fulgida* [in prairie plantings]), two endangered species (*Epilobium ciliatum* and *Zannichellia palustris*), two threatened species (*Thalictrum pubescens* and *Veronica anagallis-aquatica*) and four species on the watch list (*Filipendula rubra*, *Panax quinquefolium*, *Spiranthes ovalis* and *Synandra hispidula*) compiled by the Indiana Natural Heritage Program. The physical and biotic history of the site is reviewed, and the major community types (upland forest, floodplain forest, wetlands, aquatic and successional) are described.

Keywords: Henry County, flora, upland forest, floodplain forest, successional forest, wetlands, exotic plants

The Wilbur Wright Fish and Wildlife Area (WWFWA) is a repository for many wild plants and animals indigenous to Henry County, Indiana and the counties of the Blue River Valley drainage basin. Located approximately two miles (3 km) north of the city of New Castle, most of WWFWA is situated between the Big Blue and Little Blue Rivers. In spite of its proximity to a fairly large population center, the 416.6 ha (1029 acre) area supports a rich flora in a diversity of habitats. As a "nature preserve," it serves as a permanent habitat for the native flora and fauna of the region. However, prior to or since its establishment in August 1974, no formal botanical survey has been performed.

WWFWA is managed by of the Division of Fish and Wildlife (IDNR) whose primary management objective is to maximize game populations for public hunting. Currently, the management activities include mowing and disking of open fields to maintain an early successional plant community. In addition to open fields, much of the eastern half of WWFWA contains a variety of forest habitats, ranging from morainic ridgetop forest to bottomland forest. WWFWA is notable in that it contains one of the largest remaining sections of natural forest in east-central Indiana. Forests in this area have been greatly reduced through clearing for wood products, farming and urbanization.

An inventory of resources is the necessary first step in developing a long-term resource management plan. In determining a classification system for the natural regions of Indiana, Homoya et al. (1985) used floral species composition and distribution as an important component for delineating various natural regions. Species presence and absence reveal much about the landscape. Demographic information is also important to determine if the numbers of individuals or populations of a species are increasing, decreasing or stable (Schemske 1994). An inventory is the simplest means to document species diversity and is a fundamental step in monitoring changes that may occur in species composition. Meier

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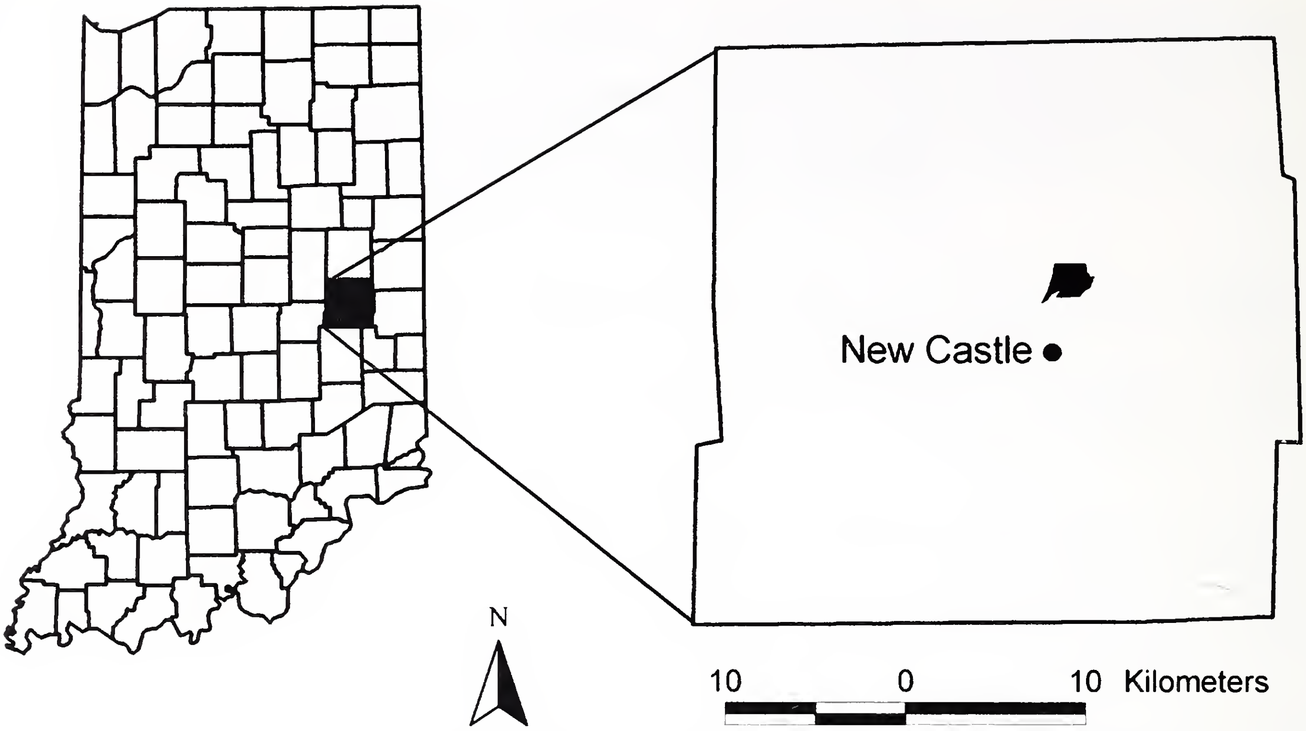

Figure 1.—Location of Henry County, Indiana (left) and the location of the Wilbur Wright Fish and Wildlife Area north of New Castle (right).

et al. (1995) found that even small forest stands, in the size ranges typical of those found in east central Indiana, are important reserves of vernal herb diversity. Additionally, measures of diversity are frequently seen as indicators of the well-being of ecological systems (Magurran 1988). These quantitative, as well as qualitative, measurements of vegetation are essential to wildlife management and research (Higgins et al. 1994).

This study has two goals: first, to inventory the vascular flora; and second, to describe the relative abundance and distribution of each species. Additionally, it is an important component of a regional survey of biodiversity in east-central Indiana (Badger et al. 1998; Rothrock et al. 1993; Rothrock 1997; Ruch et al. 1998).

THE STUDY AREA

WWFWA, consisting of 416.6 ha, is located approximately 3.2 km north of the city of New Castle in Henry County, Indiana (Sections 1, 2, and 3, Township 17 North, Range 10 East; and Sections 35 and 36, Township 18 North, Range 10 East) (Fig. 1). The property is bordered on the north by County Road (CR) 250 N to the east of State Road 103 and by the hypothetical extension of CR 250 N west of SR 103 to the Blue River; on the west by the Big Blue River; on the southwest by the Little Blue River and an abandoned railroad right-of-way which forms an inverted "V," and on the southeast by CR 150 North; and on the southern two-thirds of the east side by Hillsboro Road (Fig. 2). The northern one-third boundary of the east side wanders irregularly along various private properties. WWFWA is divided into four units. Units 1 and 2 lie to the east of SR 103, while Units 3 and 4 lie to the west. Unit 1 is separated from Unit 2 by the Little Blue River, and Unit 3 is separated from Unit 4 by CR 200 N (Fig. 2). A new state prison facility is located across the Big Blue River from Unit 4 near CR 200 N. The property is owned by the IDNR Division of Fish and Wildlife.

WWFWA lies within the eastern third of the Tipton Till Plain Section of the Central Till Plain Natural Region (Homoya et al. 1985) or in the Castle Till Plain and Drainageway of the Central Till Plain Natural Region (Gray 2000). This portion of the state is characterized by flat to gently rolling terrain, the result of continental glaciation during which glacial till and outwash were deposited as the ice advanced and retreated from Indiana during the Wisconsinan glacial stage (Hedge 1997; Melhorn 1997). Thus, all features of the

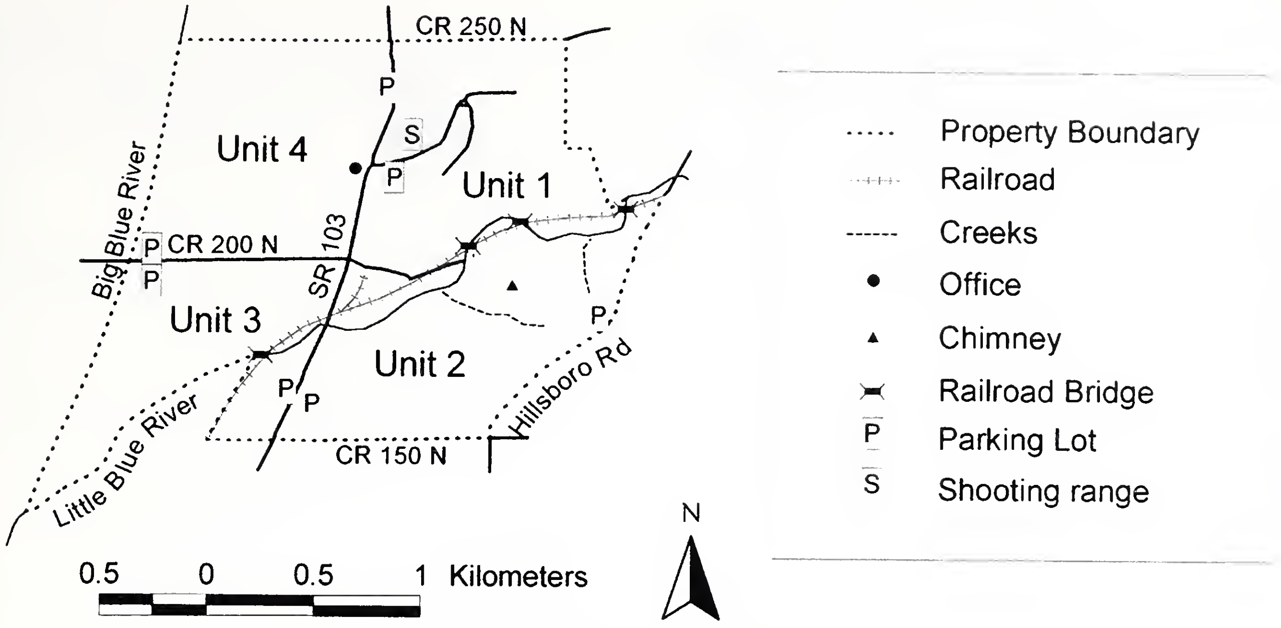

Figure 2.—Map of the Wilbur Wright Fish and Wildlife Area.

Tipton Till Plain either are glacial in origin or were formed by stream erosion in late to post-glacial time. Because the Blue River Valley was formed many millennia ago by meltwater discharge, the valley seems very wide for the size and age of the Big Blue River running through it. According to Gray (1997), "This valley is part of a complex that formed along the margin of a wasting glacier. Intermixed slices of till and gravel mark this as the site of a group of sub-ice tunnels, or of ice-walled channels that carried meltwater from inner parts of the glacier to its margin, whence the meltwater flowed down what is now the valley of the Blue River."

Geologically, WWFWA lies on the western side of the Cincinnati Arch. The property sets on a bedrock of limestone and dolostones of Silurian origin (Thompson 1997). The bedrock is overlain by a mass of unconsolidated material (e.g., the glacial till and soil layers above) that is between 15–60 m and the landscape is strewn with abundant large crystalline erratics (glacial erratics) (Indiana Geological Survey 2001a; Phinney 1886). Franzmeier (1997) describes the area as having a "thin loess over glacial till." The eastern half of Units 1 and 2 are morainic deposits from the Knightstown Morainic System, formerly known as the Champaign Morainic System (Indiana Geological Survey 2001b; Malott 1922; Wayne 1965). It is on these deposits that most of the natural woodlands of WWFWA occur.

The soils in WWFWA are varied but can be summarized into a few general categories. Most of the soil in Units 3 and 4 are Westland silt loam. Unit 4 also has a large area of Martisco muck. These soils are described as being deep, nearly level, very poorly drained, medium textured or mucky soil formed in glacial outwash sediments and organic deposits (USDA 1987). In WWFWA these soils occur in the Blue River Valley plain east of the river. Although described as being poorly drained, these areas were tiled and drained and used by the Department of Mental Health (see land-use history below) for row crops. The soils of the upsloping eastern one-third of Unit 4 and most of Unit 1 are Eldean silt loam or Eldean clay loam. At WWFWA these areas are nearly level to strongly sloping (up to 18% or more), have well drained, medium to moderately fine textured soils that are moderately deep lying over sand and gravel (USDA 1987). Nearly all of the springs (e.g., seeps, fens, etc.) at WWFWA occur within Eldean map units. The soils in the forested area of Unit 2 are mostly Losantville silt loam with some Miamian silt loam. These soils are level to steep, usually well drained, and of medium to moderately fine texture (USDA 1987). At WWFWA these soils cover the wooded morainic deposit from the Knightstown Morainic System. This area has several woodland seeps and a few springs forming small creeks that drain into the Little Blue River. Two small headwater creeks have eroded the woodland terrain forming small,

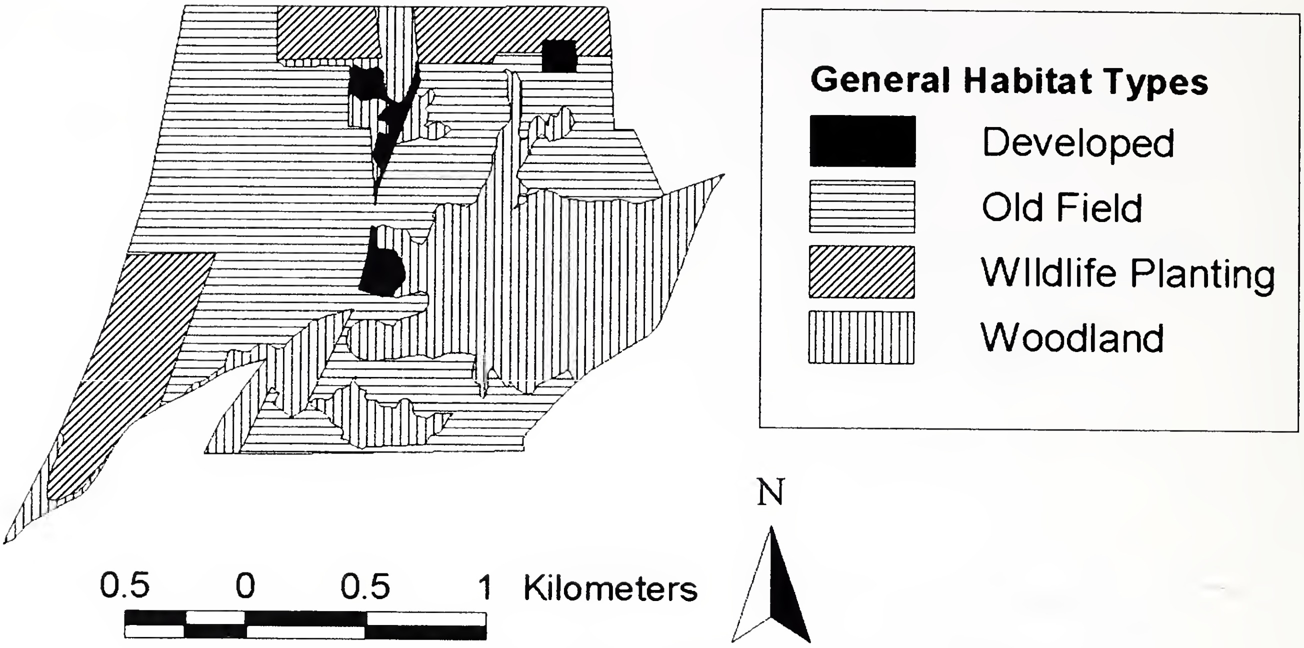

Figure 3.—Habitat types of the Wilbur Wright Fish and Wildlife Area.

moist, botanically rich ravines. Several plant species only occur in these ravines and their accompanying alluvial plains.

Flatwood communities are common in the Tipton Till Plain section. Characterized by having poorly drained soils with many shallow depressions that are seasonally wet, these communities apparently do not occur at WWFWA. This is in part because the flat areas of the property, e.g., Units 3 and 4, have been tiled and drained for row crop farming when the Department of Mental Health owned the land. The morainic ridge-top forest, slope forest, and bottomland forests are moderate to very well drained. We only found three very small vernal pools in the woodland area. The principal habitats that occur in WWFWA are old fields (some with prairie plantings), developed, morainic ridge-top forest, slope forest, bottomland or floodplain forest, black locust plantings, hillside seeps, calcareous fens, and sedge meadows (Fig. 3).

The head of the Blue River lies approximately 11.3 km north and east of WWFWA in the general depression within which Summit Lake now resides. According to Potzger (1935), this area of the Blue River Valley was the site of "an ancient lake with shore lines sharply marked by high ridges and knolls. When civilized man [*European settlers*] first came to Henry County, this ancient lake was a wet swamp into which numerous springs drained." At that time, the head of the Blue River was a powerful bubbling spring (Potzger 1935), but at present the source is hidden below Summit lake. The upper Blue River Valley, where WWFWA is located, lies in the White River basin, specifically in the Driftwood Watershed (USGS Cataloging Unit 05120204). The Big Blue River, along with several other rivers in this watershed flow south and west, eventually forming the East Fork of the White River near Columbus, Indiana.

LAND USE HISTORY

Potzger (1935) hypothesized that following the Wisconsinan glacial age, the once powerful Blue River dwindled in water volume as the glaciers retreated, and the shallowing outer reaches of the river evidently supported aquatic and helophytic vegetation that gradually filled in the shallow water. Mosses then invaded, and in time the valley developed into a cedar-tamarack (*Thuja* and *Larix*) bog. Over the millennia the decay of mosses and other plant material left a thick layer of peat (0.6–1.8 m in depth) especially near the Blue River. Potzger (1935) further postulated that some catastrophic influence, possible fire, occurred during the time when the cedar-tamarack forest had been reduced to a relic colony by an advancing broad-leaved forest. He suggested that the fire might have been the immediate cause for the complete destruction of the

Table 1.—Wilbur Wright fish and wildlife area land acquisition time line.

Date	Acreage (ha)	Description of transfer
7 February, 1972	344.13	Transferred from Indiana Village of the Epileptics to IDNR Division of State Parks.
1 August, 1974	344.13	Transferred from IDNR Division of State Parks to IDNR Division of Fish and Wildlife.
24 October, 1980	0.19	House site on Hillsborough Rd. transferred from Mental Health to IDNR Division of Fish and Wildlife (house demolished).
24 October, 1980	1.21	Residential site along west side of SR103 and CR 250 N (buildings demolished).
18 July, 1990	46.96	Unit 2 transferred from Mental Health to IDNR Division of Fish and Wildlife.
6 August, 1991	1.67	Residential site transferred from Mental Health to IDNR Division of Fish and Wildlife (buildings demolished).
28 May, 1999	16.19	Land south of Department of Corrections Facility, west of Blue River, and East of old Railroad bed transferred from Department of Corrections to IDNR Division of Fish and Wildlife.
8 June, 1999	6.07	Service area in Unit 1 transferred from Mental Health to IDNR Division of Fish and Wildlife. The Department of Corrections is currently using this area.

northern forest and the initiation of a sedge meadow community.

Prior to European settlement, the Tipton Till Plain Section of Indiana was primarily covered with beech-maple forest (Homoya et al. 1985). Review of original land survey data collected by General Land Office (GLO) surveyors between 1820–1821 reveals that several other plant communities may have existed including wet-mesic prairie and oak-hickory community types. The upper Blue River Valley floor was covered by an intermittent lowland forest and sedge-covered flats (Potzger 1935). No conifers were in the valley when the settlers first moved into the region (Potzger 1935). The GLO land survey data indicates that the morainic ridge on the eastern side of WWFWA was largely forested at the time of settlement.

In the 1890s the Big Blue River channel was dredged. The dredging lowered the water table of the adjacent land so that the area could be used for agriculture (Potzger 1935).

In March of 1906, the State of Indiana purchased 416.6 ha, which included most of the present WWFWA. From this time until the land was transferred to IDNR Division of Fish and Wildlife in 1972, it was under the management of the Department of Mental Health. Through extensive tiling, much of the valley floor (e.g., Units 3 and 4 of WWFWA) was either cultivated or pastured. Units 1, 2, and 4 also contained some building sites (Fig. 3). While under Department of Mental Health ownership, the property was a state-operated farm with patients housed at the Village for the Epileptics providing labor. In 1969, the state farming operation was closed (New Castle State Hospital 1980). Portions of the property, mainly in Units 3 and 4, remained in row crops through the late 1990's. WWFWA consists currently of old field and wooded habitats. Portions of old field habitats in all units are intensively managed for public hunting through mowing, disking, and plowing (Schuyler pers. comm.). Table 1 lists the time line of land acquisition for WWFWA. The area covered in this study includes all land acquired before 6 August 1991, e.g., approximately 392.3 ha.

METHODS

During the late summer and fall of 1999 and the 2000 and 2001 growing seasons, one to four forays per week were made into the study area. Voucher specimens of each species observed were collected and have been deposited in the Ball State University Herbarium (BSUH). Notes on vegetation consisted of species lists with visual estimates of their abundance (see catalog of vascular plants). Additionally, seasonal changes in the dominant vegetation (bases on time of flowering) were noted for many of the varied habitats.

Nomenclature of pteridophytes and gymnosperms follows the *Flora of North America*, Volume 2 (Morin et al. 1993). Except for the Cyperaceae and the Poaceae, nomenclature of the Magnoliophyta follows Gleason & Cronquist (1991). The Cyperaceae and Poaceae follow the nomenclature of Swink & Wilhelm (1994). Species were deemed unreported for Henry County if they did not appear in the computer database of Keller et al. (1984). Within the catalog of vascular flora, each species is followed by its common name(s) based primarily on Gleason & Cronquist (1991), a visual estimate of its relative abundance, its typical habitat in the study area, and a Ball State University Herbarium (BSUH) number(s). The relative abundance for species is defined as follows: rare = < 5 sites although a species may be abundant at one site; infrequent = occasional, not widespread throughout its potential habitats, but may be locally abundant at a site; frequent = common throughout its potential habitats and may be locally abundant at one or more sites; and abundant = common and numerous throughout its potential habitats.

RESULTS

The catalog of the vascular flora of the Wilbur Wright Fish and Wildlife Area contains 635 species representing 343 genera and 109 families. Thirty-three families are represented by only one species. A comparison with the Indiana Natural Heritage Data Center's records for Henry County suggests that the county was poorly collected since a total of 274 species and varieties are recorded for the first time. Of the 611 angiosperms listed, 163, or approximately 27%, are non-native or exotic species. The ten families with the highest number of species are the Asteraceae (76 species), Cyperaceae (55 species, including 44 *Carex* spp.), Poaceae (53 species), Rosaceae (30 species), Liliaceae (23 species), Lamiaceae (21 species), Ranunculaceae (19 species), Brassicaceae (18 species), Fabaceae (17 species), and Apiaceae (16 species). Based on the list compiled by the Indiana Natural Heritage Program (3 May 1996 draft, available from the Indiana Natural Heritage Program), the status of several plant at WWFWA is as follows: Rare: *Rudbeckia fulgida* var. *fulgida*; Endangered: *Epilobium ciliatum* and *Zannichellia palustris*; Threatened: *Thalictrum pubescens* and *Veronica anagallis-aquatica*; and on the Watch List: *Filipendula rubra*, *Panax quinquefolium*, *Spiranthes ovalis*, and *Synandra hispidula*. The location and dbh of some of the largest trees are shown in Fig. 4.

Habitat Descriptions

Vegetational communities at WWFWA are very diverse, due both to complex topography and a variety of land uses in the past and at present. Plant communities therefore reflect both original natural types as well as types that have originated through human disturbance and introduction of alien species. Both natural and anthropogenic communities, especially the later, are in various stages of ecological succession and development.

Natural communities in WWFWA, although affected by periodic logging, clearing, introductions of alien species and other disturbance, nevertheless retain much of the characteristic plant associations of this region. These include both forest (upland and floodplain forests) and wetland communities. Other community types are more strikingly anthropogenic; these include open fields, meadows, thickets and early successional woodlands. Figure 3 outlines general habitat types. A broader description of each habitat follows.

Upland forest.—The upland forest occupies much of the land in Unit 2, encompassing two headwater tributary valleys and the land in between. It also occurs in Unit 1 and Unit 3 in small, very disturbed stands. This deciduous forest type is significantly different from the poorly-drained flatwoods type occurring on the Tipton Till Plain to the west (Badger et al. 1998; Ruch et al.1998). Tree species present are characteristic of well-drained soils, e.g., *Carpinus caroliniana*, *Carya cordiformis*, *C. ovata*, *Fagus grandifolia*, *Fraxinus americana*, *Juglans nigra*, *Liriodendron tulipifera*, *Ostrya virginiana*, *Quercus alba*, and *Q. rubra*. Other tree species occurring in the upland forest include *Acer saccharum*, *Aesculus glabra*, *Carya glabra*, and *Tilia americana*. Common woody vines are *Parthenocissus quinquefolia*, *Smilax hispida*, *Vitis riparia*, and *V. vulpina*. Common shrubs include *Lindera benzoin*, *Ribes cynosbati*, and *Viburnum prunifolium*. Ground plants include *Agrimonia pubescens*, *Alliaria petiolata*, *Allium tricoccum*, *Anemonella thalictroides*, *Arisaema triphyllum*, *Asarum canadense*, *Asplenium pla-*

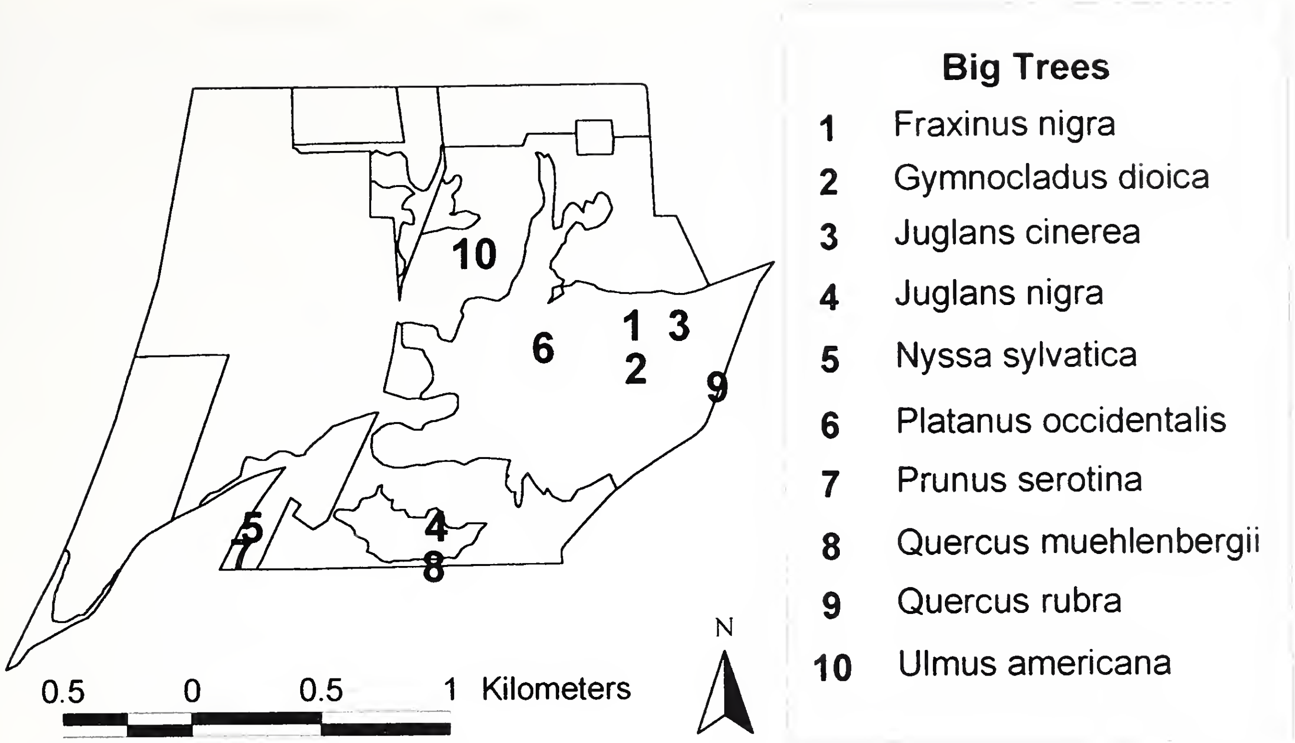

Figure 4.—Location of some of the largest trees at Wilbur Wright Fish and Wildlife Area. 1 = *Fraxinus nigra*, dbh = 50.0 cm; 2 = *Gymnocladus dioica*, dbh = 64.3 cm; 3 = *Juglans cinerea*, dbh = 63.0 cm; 4 = *Juglans nigra*, dbh = 80.2 cm; 5 = *Nyssa sylvatica*, dbh = 78.3 cm; 6 = *Platanus occidentalis*, dbh = 242.9 cm; 7 = *Prunus serotina*, dbh = 103.0 cm; 8 = *Quercus muehlenbergii*, dbh = 110.9 cm; 9 = *Quercus rubra*, dbh = 148.5 cm; 10 = *Ulmus americana*, dbh = 89.6 cm.

tyneuron, *Aster cordifolius*, *A. lateriflorus*, *A. sagittifolius*, *A. shortii*, *Botrychium virginianum*, *B. dissectum*, *Camassia scilloides*, *Campanula americana*, *Cardamine concatenata*, *C. douglassii*, *Circaea lutetiana*, *Claytonia virginica*, *Cystopteris protrusa*, *Dicentra cucullaria*, *Elymus hystrix*, *Erigenia bulbosa*, *Erythronium americanum*, *Euonymus obovatus*, *Eupatorium rugosum*, *Galium concinnum*, *Geranium maculatum*, *Geum canadense*, *Hydrophyllum appendiculatum*, *H. macrophyllum*, *Isopyrum biternatum*, *Juncus tenuis*, *Lactuca floridana*, *Luzula multiflora*, *Orchis spectabilis*, *Osmorhiza longistylis*, *O. claytoni*, *Phlox divaricata*, *Podophyllum peltatum*, *Polemonium reptans*, *Polygonatum biflorum*, *Polygonum virginianum*, *Prenanthes altissima*, *Ranunculus micranthus*, *Ruellia strepens*, *Sanguinaria canadensis*, *Sanicula gregaria*, *S. trifoliata*, *Silene virginica*, *Solidago caesia*, *Stellaria pubera*, *Trillium flexipes*, *T. recurvatum*, *T. sessile*, *Uvularia grandiflora*, *Viola pubescens* and *V. sororia*. In addition, approximately 20 species of *Carex* occur in these woodlands. Although much of this forest type lies on uplands and gentle slopes and is fairly uniform in composition, several community subtypes occur within the boundaries of the mixed mesophytic forest. These are mostly shaded and some could be considered wetlands. Several of these sites are described below.

Steeper slopes and ravines: This type is only poorly differentiated from the mesophytic forest of upland areas. However, certain plants tend to favor this habitat, including *Diplazium pycnocarpon*, *Fraxinus quadrangulata*, *Hepatica acutiloba*, *Mitella diphylla*, *Polystichum acrostichoides*, *Ranunculus hispidus*, *R. recurvatus*, *Quercus muehlenbergii*, *Solidago flexicaulis*, *Thalictrum dioicum*, and several *Carex* spp.

Depositional banks and alluvial plains of streams: This habitat is found in the lower reaches of both headwater streams in Unit 2. It is subject to brief flooding during heavy rains and its depositional soils are deep and rich. *Cryptotaenia canadensis*, *Laportea canadensis*, *Leersia virginica*, *Lobelia siphilitica*, *Mimulus alatus*, *Ranunculus hispidus*, and *Valeriana pauciflora* are characteristic species.

A rather similar, but unshaded, plant community is found where the northern headwater stream in Unit 2 ends by subsidence into the bottomland soils of the Little Blue River Valley. Here soft, wet soils promote the tipping and falling of any sizable trees and hence an open meadow results. This habitat supports many of the species listed for alluvial plains as well as *Aster puniceus*, *Cardamine rhomboidea*, *Carex* spp., *Equisetum arvense*, *Eupatorium maculatum*, *E. perfoliatum*, *Senecio aureus*, *Valerianella umbilicata* and several species of grass. A large individual *Juglans cinerea* is located on the western edge of this meadow.

Skunk cabbage seep: This community occurs on a shaded seepage area at the base of the north-facing slope of the Blue River Valley in Unit 2. It is about 100 m long and as much as 10 m wide. The soft, mucky organic soil is occupied almost exclusively by *Symplocarpus foetidus* (skunk cabbage). Other plants that occur in association with the margin of this seep, or the seep itself, and were found almost nowhere else in this study include *Caltha palustris*, *Cornus alternifolia*, *Smilacina stellata*, and *Senecio aureus*.

Hydrangea seeps: These also occur mostly on steep, wet slopes of the Little Blue River Valley in Unit 2. These rather small communities are dominated by *Hydrangea arborescens*, sometimes occurring with *Equisetum hyemale*.

Scouring rush seeps: These communities consist of dense stands of *Equisetum hyemale*, often to the virtual exclusion of other plants. These occur on both shaded and open slopes, river bottomlands, wet fields and old railroad beds or wherever there is a slow discharge of moisture from the soil.

Woodland ephemeral ponds: Only three small examples were found, all in Unit 2. A number of plants occurred in the dried pond next to parking area 2A, including *Carex davisii*, *C. grayi*, and *C. tribuloides*.

Camass swales: These consist of shallow, gently sloping valleys carrying rainwater runoff into headwater streams within the forest. They typically support large dense colonies of *Camassia scilloides* in spring. Other plants include *Cryptotaenia canadensis*, *Laportea canadensis* and *Physostegia virginiana*.

Dry hilltops and south-facing dry slopes: The topography and open canopy of this habitat permits sunlight to penetrate to the forest floor. This provides a partially sunny but very dry situation quite different from most of the forest. In some respects, the margins of a recovering clear-cut in between the headwater streams of Unit 2 provides a similar habitat where *Heuchera americana* and *Scutellaria ovata*, both typically species of dry wooded slopes, have become established. A dry, south-facing slope community is found just southeast of the junction of the south headwater stream and the Little Blue River. The plants that occur here include *Antennaria plantaginifolia*, *Arabis laevigata*, *Cacalia atriplicifolia*, *Carex pensylvanica*, *Dodecatheon meadia*, *Luzula multiflora*, *Quercus velutina*, *Silene virginica*, *Thaspium trifoliatum*, and *Tradescantia virginiana*. Most of these species occurred only at this site.

Successional forests: Much of the original forest in Unit 2 is now bounded by areas that are undergoing succession. Furthermore, a 25+ year old clear-cut area, located between the two headwater streams, is also undergoing similar succession. These "new," young forests are adjacent to native vegetation seed sources. Thus, they are tending toward a more archetypal successional process than many other areas at WWFWA where seed sources of native communities are more remote. Many of these successional forests occur were lawns with buildings once stood. Some of these retained original oaks and other species as lawn trees. The buildings were gradually removed in the 1960–1970 time period, and the areas have been invaded by *Campsis radicans*, *Crataegus* spp., *Elaeagnus umbellata*, *Rosa multiflora*, and *Syringa vulgaris*. These species are persisting but are gradually being overtopped by larger, sun tolerant trees, such as *Acer platanoides*, *Fraxinus americana*, *Gleditsia triacanthos*, *Prunus serotina*, *Ulmus americana*, and *U. pumila*. Concurrently, herbaceous woodland plants have begun to colonize these successional forests. Species such as *Chaerophyllum procumbens* and *Liparis liliifolia* were found only in these areas. Additionally, in successional forests dominated by *Crataegus* spp. and *Acer platanoides*, the ground cover through spring and early summer consisted almost exclusively of *Galium aparine* and *Stellaria media*.

Floodplain forest.—A second major forest type is the floodplain forest. At WWFWA this plant community is represented by the Little Blue River Valley bottomlands in Units 1, 2, and 3. This forest usually has an understory dominated by *Acer negundo*. Larger trees include *Aesculus glabra*, *Celtis occidentalis*, *Fraxinus pennsylvanica*, *F. nigra*, *Juglans nigra*, *Platanus occidentalis*, *Populus deltoides*, and *Ulmus americana*. One sycamore in Unit 2, recently dead, is *ca.* 2.44 m in diameter. Shrubs include *Lonicera* × *bella*, *L. morrowii* and *Sambucus canadensis*. The herbaceous flora includes *Ambrosia trifida*, *Cryptotaenia canadensis*, *Elymus riparius*, *E. virginicus*, *Galium triflorum*, *Helenium autumnale*, *Heliopsis helianthoides*, *Humulus lupulus*, *Impatiens capensis*, *I. pallida*, *Isopyrum biternatum*, *Laportea canadensis*, *Monarda clinopodia*, *Osmorhiza longistylis*, *Pilea pumila*, *Rudbeckia laciniata*, *Sanicula gregaria*, *Silphium perfoliatum*, *Stachys tenuifolia*, *Urtica dioica*, *Verbesina alternifolia*, and *Viola striata*. Bur oaks, *Quercus macrocarpa*, have become established on the Little Blue River Valley east of the bridge on State Road 103. Although the floodplain forest has fewer special communities and less diversity than the upland mesophytic forest, one could delineate riverbanks and old riverbed depressions as subcommunity types.

Wetlands.—The open, unshaded natural communities that persist or have re-established are all wetland community types. A large wetland complex is found north of the Little Blue River in Unit 1. Other unshaded wetlands cover large areas in Units 3 and 4. Most of these wetlands have been restricted by drain tile installation and were formerly of larger dimensions. Major invasive exotic species in wetlands of all types include *Dipsacus sylvestris*, *Lysimachia nummularia*, *Morus alba*, and *Phalaris arundinacea*. Additionally, *Elaeagnus umbellata* and *Pastinaca sativa* invade the slightly drier marginal regions. Natural wetland communities include several distinct subtypes described below.

Sedge meadows: Several species of *Carex* dominate individual meadows, often to the exclusion of other plants. Sedge meadow communities occupy very moist ground and are less than one hectare in size. They are most often located at the base of gentle slopes. In Unit 1, a large sedge meadow with four distinct and recognizable subcommunities lies along the base of the river valley slope. The first subcommunity (at the northern end) is nearly a monoculture of *Carex trichocarpa*; the second is a mixture of *Carex* spp., *Eleocharis palustris*, *Juncus tenuis*, *J. torreyi*, *Pycnanthemum virginiana*, *Rudbeckia hirta* and other plants; the third is a dense stand of *Carex stricta* with *Filipendula rubra*, *Pycnanthemum virginiana*, and *Rudbeckia hirta*; and the fourth is a mixed stand of *Carex* spp., including *C. lurida* and *C. hystericina*, with *Typha angustifolia*, *T. latifolia* and many forbs, some characteristic of calcareous habitats, such as *Bidens coronata* and *Lysimachia quadriflora*. Several more sedge meadows in Units 1, 3, and 4 include large monocultures of *Carex atherodes*, *C. emoryi*, *C. stricta*, and/or *C. vulpinoidea*. The large *C. atherodes* meadow in Unit 1 occurs in the flat floodplain of the Big Blue River and is nearly surrounded by *Phalaris arundinacea*. Other species of *Carex* occur in wet fields and mixed wetland communities often being dominant plants in such situations.

Shrub-carr: Much of the open wetlands of Units 1, 3, and 4 are covered with dense stands of willows, especially *Salix exigua* and *S. nigra*. The large sedge meadow in Unit 1, discussed above, is bordered in part by stands of *Cornus amomum*, *Rosa setigera*, and *Sambucus canadensis*.

Cattail marsh: A narrow band of cattails occurs along the edges of the four sedge meadow communities in Unit 1. This area is wetter than the sedge meadow communities, often with standing water. *Typha latifolia* associates here with *Eupatorium perfoliatum*, *Lycopus americana*, *Mentha arvensis*, *M.* × *gentilis*, *Solanum dulcamara*, *Stachys tenuifolia*, and *Verbena hastata*.

Sweet flag swales: Along the northern bank of the Little Blue River in Unit 1, a raised ridge separates the present river channel from a former river bed now occupied by dense stands of sweet flag (*Acorus calamus*). These were probably planted. *Acorus calamus* is a triploid sterile exotic (Thompson 1995, 2000) which had formerly not been separated from the native species (Deam 1940). These stands are bordered to the north by the cattail stands and the four sedge meadow communities discussed above. Here the water depth is greater (up to 6 inches) (25 cm) than that of the cattail marsh, but these swales often dry up by mid summer. Although few species are able to grow among the sweet flag rhizomes, those that do include *Aster puniceus*, *Lycopus amer-*

icanus, *L. uniflorus*, *Ranunculus hispidus* var. *caricetorum*, *Stachys tenuifolia*, *Valerianella umbilicata*, *Verbena hastata*, and in some places *Leersia oryzoides*.

Fens: All of the fens at WWFWA are, at least in part, severely disturbed and unshaded. They have distinct springs with rivulets that flow throughout the year. All of these rivulets appear to eventually enter field drain tiles that carry their water to the rivers. Of the two fens in Unit 1, one is dominated by sweet flag plantings and *Muhlenbergia mexicana*, although it has a small sedge meadow in its upper portion. The other has been severely disturbed and is dominated by *Impatiens capensis*, *Rosa multiflora*, and *Sambucus canadensis*. In Unit 4, just west of the parking lot 1A on Indiana Highway 103, several small fens, some dominated by sweet flag plantings and some severely disturbed, can be found. Whether or not any of these fens can be considered natural plant communities, even in part, is very questionable.

Aquatic plant communities.—The Little Blue River, a shaded stream in a forested valley, has virtually no truly aquatic plants. Even *Sagittaria latifolia* occurs only on the banks. Colonies of *Lemna minor* and *Wolffia papulifera* may develop in quiet backwaters if sufficient sunlight is available. On the other hand, the Big Blue River lies in cleared land, free of shade, and has been excavated into a long straight channel. Here the river bed is usually covered by submerged macrophytes, including *Ceratophyllum demersum*, *Myriophyllum* sp., *Potamogeton crispus*, *P. pectinata*, and *Zannichellia palustris*. Colonies of *Rorippa nasturtium-aquaticum* and *Veronica anagallis-aquatica* occur along the bank margin wherever ground water enters the river directly. A small pond, probably artificial, is found below a disturbed fen in Unit 4, receiving its water from the spring water rivulet. *Potamogeton foliosus* and *Lemna minor* are the only true aquatic plants in this pond.

Successional (anthropogenic) communities.—Most anthropogenic plant communities are developing on sites of former lawns, buildings, and agricultural fields. Such areas, which are adjacent to natural forest communities, are undergoing succession to native forest (described earlier). However, sites more distant from native plant community remnants are undergoing various types of successional development, involving both native and exotic species. Furthermore, management for wildlife habitat in some areas includes both mowing and tilling. Mesic old fields are typically dominated by such plants as *Bromus inermis*, *Dactylis glomerata*, *Daucus carota*, *Elaeagnus umbellata*, *Festuca elatior*, *Geum laciniatum*, *Lonicera maackii*, *Rosa multiflora*, and *Solidago canadensis*. Fields recently released from row crops are dominated by plants of early succession, including *Abutilon theophrasti*, *Amaranthus retroflexus*, *Barbarea vulgaris*, *Brassica nigra*, *Bromus commutatus*, *Datura stramonium*, *Erigeron annuus*, *Hibiscus trionum*, *Lactuca serriola*, *Panicum capillare*, *Physalis longifolia* var. *subglabrata*, *Portulaca oleracea*, *Sisymbrium loeselii*, *Solanum carolinense*, *S. nigrum*, and *Torilis arvensis*. Prairie plantings have been made in Units 1 and 3. These consist of *Andropogon gerardii*, *Schizachyrium scoparium*, and *Sorghastrum nutans* with various forbs. Many old fields have grown into thickets and successional woods. Plowed edges, black locust (*Robinia pseudoacacia*) groves, roadsides, ditches, dry hillsides, and conifer plantings are other vegetational community types present that could be distinguished.

Perhaps the most distinctive man-induced plant community on the property is a small area north of the Little Blue River along State Road 103 in Unit 1. This site, hereafter called the cindery, is an area of approximately 0.2–0.3 ha covered with a layer of crushed cinders from an old heating plant. Plants that occurred here, but nowhere else, are *Diodia teres*, *Froelichia gracilis*, *Plantago aristata*, *Silene antirrhina*, and *Sporobolus vaginiflorus*. Although occurring elsewhere on the property, *Mollugo verticillata* and *Poa compressa* are particularly abundant here.

Exotics

As stated above, approximately 27% of the angiosperms (164 of 611 species and varieties) at WWFWA Wright are non-native. This is expected since the Village for the Epileptics was housed at this site for several decades. During that time, many of the exotics currently at WWFWA were planted for landscaping or gardening. However, most of these ornamental plants are not exhibiting evidence of spreading. These include *Acer platanoides* cv. Schwedleri, *Alnus glutinosa*, *Asparagus offi-*

cinalis, *Berberis thunbergii*, *Betula nigra*, *Campanula rapunculoides*, *Chaenomeles speciosa*, *Chelidonium majus*, *Convallaria majalis*, *Euonymus fortunei*, *Hesperis matronalis*, *Iris germanica*, *Lespedeza bicolor*, *Lonicera tatarica*, *Narcissus poeticus*, *N. pseudonarcissus*, *Ornithogalum umbellatum*, *Pyrus malus*, *Rosa canina*, *Salix pentandra*, *S. purpurea*, *S.* × *rubens*, *Tilia cordata*, *Viburnum opulus* var. *opulus*, and *Weigela florida* and *Zea mays*. Exotics found in prairie plantings that appear not to be spreading include *Carduus nutans*, *Coreopsis grandiflora*, *C. tinctoria*, *Helianthus maximilianii*, *Mirabilis nyctaginea*, and *Papaver rhoeas*. Exotic species confined to the grounds around the office building include *Euonymus alatus*, *Forsythia* × *intermedia*, *Iris pseudacorus*, *Sedum sarmentosum*, and *Spiraea vanhoutei*.

A few exotic ornamentals are spreading from their original sites. Those spreading slowly include *Acorus calamus*, *Artemisia ludoviciana*, *Celastrus orbiculatus*, *Commelina communis*, *Hemerocallis fulva* (vegetative expansion only), *Ligustrum vulgare*, *Malva neglecta*, *Medicago sativa*, *Prunus cerasus*, *Viola priceana*, and *Yucca filamentosa*. Those that are invasive and expanding quickly include *Acer platanoides* (especially in Unit 2 woods), *Coronilla varia* and *Lotus corniculatus* (planted to reduce roadside erosion), *Elaeagnus umbellata* (planted for wildlife), *Morus alba*, *Nepeta cataria*, *Rosa multiflora*, *Saponaria officinalis*, *Silene latifolia*, *Syringa vulgaris*, and *Ulmus pumila*.

The origin of the non-ornamental exotics and grasses is unclear or unknown. Within this group of plants are a few species that are not exhibiting signs of expansion, including *Brassica kaber*, *Chaenorrhinum minus*, *Plantago major*, and *Polygonum hydropiper*. Most of the non-ornamental exotics at WWFWA appear to be expanding their range at various rates, although some were undoubtedly planted or sown as seed. These include *Abutilon theophrasti*, *Achillea millefolium*, *Alliaria petiolata*, *Allium vineale*, *Amaranthus powellii*, *A. retroflexus*, *Arctium minus*, *Arenaria serpyllifolia*, *Barbarea vulgaris*, *Brassica nigra*, *Capsella bursa-pastoris*, *Centaurea maculosa*, *Cerastium vulgatum*, *Chrysanthemum leucanthemum*, *Cichorium intybus*, *Cirsium arvense*, *Conium maculatum*, *Convolvulus arvensis*, *Datura stramonium*, *Daucus carota*, *Dianthus armeria*, *Dipsacus sylvestris*, *Draba verna*, *Froelichia gracilis*, *Geranium pusillum*, *Glechoma hederacea*, grasses [*Bromus commutatus*, *Bromus inermis*, *Bromus japonicus*, *Bromus racemosa*, *Bromus tectorum*, *Dactylis glomerata*, *Digitaria ischaemum*, *Eleusine indica*, *Elytrigia repens*, *Eragrostis cilianensis*, *Lolium perenne* var. *perenne*, *Phalaris arundinacea*, *Phleum pratense*, *Poa annua*, *Poa compressa*, *Poa trivialis*, *Setaria faberi*, *Setaria glauca*, *Setaria viridis*, and *Sorghum halepense*], *Hibiscus trionum*, *Holosteum umbellatum*, *Hypericum perforatum*, *Ipomoea hederacea*, *I. purpurea*, *Lactuca saligna*, *L. serriola*, *Lamium amplexicaule*, *L. purpureum*, *Leonurus cardiaca*, *Lepidium campestre*, *Linaria vulgaris*, *Lithospermum arvense*, *Lonicera japonica*, *L. maackii*, *L. morrowii*, *Lysimachia nummularia*, *Maclura pomifera*, *Matricaria matricarioides*, *Medicago lupulina*, *Melilotus alba*, *M. officinalis*, *Mollugo verticillata*, *Pastinaca sativa*, *Plantago lanceolata*, *Polygonum cespitosum*, *P. persicaria*, *Portulaca oleracea*, *Potamogeton crispus*, *Potentilla argentea*, *Potentilla recta*, *Rorippa nasturtium-aquaticum*, *Rumex acetosella*, *R. crispus*, *R. obtusifolius*, *Sisymbrium loeselii*, *Solanum dulcamara*, *Sonchus asper*, *Stellaria media*, *Taraxacum officinale*, *Thlaspi arvense*, *Torilis arvensis*, *Tragopogon* spp., *Trifolium campestre*, *T. hybridum*, *T. pratense*, *T. repens*, *Verbascum blattaria*, *V. thapsus*, *Veronica arvensis* and *Vicia cracca*.

The 15 most-invasive exotics are *Acer platanoides*, *Alliaria petiolata*, *Brassica nigra*, *Bromus inermis*, *Dipsacus sylvestris*, *Elaeagnus umbellata*, *Festuca elatior*, *Lotus corniculatus*, *Lysimachia nummularia*, *Morus alba*, *Pastinaca sativa*, *Phalaris arundinacea*, *Potamogeton crispus* (in the Big Blue River), *Rosa multiflora*, and *Sisymbrium loeselii*.

DISCUSSION

This study provides a baseline of information about native and exotic plants species at Wilbur Wright Fish and Wildlife Area. As time passes, new plant communities will gradually develop composed of both native and exotic elements. WWFWA provides a "natural laboratory" in which the behavior of native and exotic species, as well as their contributions to community development and stability, can be observed over time.

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APPENDIX 1. CATALOG OF VASCULAR PLANTS IN WILBUR WRIGHT FISH AND WILDLIFE AREA

(arranged alphabetically by family)

Following each species is information specific to its occurrence at WWFWA. This information includes the following: The symbols in parentheses immediately following each species refer to the following: * = naturalized (exotic), non-native species; + = county record; a = planted but apparently not spreading; b = horticultural variety planted, escaped and naturalized; c = planted but disappearing; z = photographed in WWFWA before this study but not found during the study period.

Relative abundance: rare = < 5 sites although a species may be abundant at one site; infrequent = occasional, not widespread throughout its potential habitats, but may be locally abundant at one site; frequent = common throughout its potential habitats and may be locally abundant at one or more sites; and abundant = common and numerous throughout its potential habitats.

The status categories of certain species in brackets (e.g., [Endangered], [Threatened], [Rare], and [Watch List]) is from the list compiled by the Indiana Natural Heritage Program (3 May 1996).

PHYLUM EQUISETOPHYTA
(Scouring Rushes)

Equisetaceae (Horsetail Family)

Equisetum arvense L.: Common or Field Horsetail; infrequent; ditches and moist meadows; BSUH 10557, 10958, 11518, 11585.

Equisetum hyemale L.: Common Scouring Rush; abundant; mesic woods and along railroad track, often in dense large colonies; BSUH 10558, 10872, 11225.

PHYLUM POLYPODIOPHYTA
(Ferns)

Aspleniaceae (Spleenwort Family)

Asplenium platyneuron (L.) Britt., Sterns & Poggen: (+); Ebony Spleenwort; common; mesic woods; BSUH 11282.

Dryopteridaceae (Wood Fern Family)

Cystopteris protrusa (Weatherby) Blasdell: (+); Lowland Brittle or Southern Bladder Fern; abundant; mesic woods; BSUH 11278.

Diplazium pycnocarpon (Spreng.) M. Broun: (+); Synonym—*Athyrium pycnocarpon* (Spreng.) Tidestrom; Narrow-leaved Glade Fern or Glade Fern; infrequent; ravines in mesic woods; BSUH 10776.

Dryopteris carthusiana (Villars) H.P. Fuchs: (+); Synonym—*Dryopteris spinulosa* (Mull.) Watt; Toothed or Spinulose Wood Fern; rare, one site; ravine in mesic woods; BSUH 11108.

Matteuccia struthiopteris (L.) Todaro: (a,+) Ostrich Fern; rare; plant next to building; BSUH 11446.

Onoclea sensibilis L.: Sensitive Fern; rare, one site; bank of Little Blue River; BSUH 10775.

Polystichum acrostichoides (Michx.) Schott: (+);

Christmas Fern; infrequent to common; ravines in mesic woods; BSUH 10556, 11277.

Ophioglossaceae (Adder's-tongue Family)

Botrychium dissectum var. *dissectum* Spreng: Lace-frond Grapefern; Dissected Grapefern; infrequent; mesic woods; BSUH 10465.

Botrychium dissectum var. *obliquum* (Muhl.): Clute Lace-frond Grapefern; abundant; mesic woods; BSUH 10587.

Botrychium virginianum (L.) Swartz: Rattlesnake Fern or Common Grapefern; abundant; mesic woods; BSUH 11279.

Pteridaceae (Maidenhair Fern Family)

Adiantum pedatum L.: Northern Maidenhair Fern; rare; mesic woods; BSUH 10466.

Thelypteridaceae (Marsh Fern Family)

Phegopteris hexagonoptera (Michx.) Fee: Synonym—*Thelypteris hexagonoptera* (Michx.) Weatherly; Broad Beech or Southern Beech Fern; rare, one site; ravine in mesic woods; BSUH 11105.

PHYLUM PINOPHYTA
(Gymnosperms)

Cupressaceae (Redwood or Cypress Family)

Juniperus virginiana L.: (a,*,+); Eastern Red Cedar; rare; planted next to building; BSUH 11437, 11655.

Taxodium distichum (L.) Rich.: (a,*,+); Bald Cypress; rare; planted in Unit 4 field; BSUH 11441.

Thuja occidentalis L.: (a,*,+); Northern White Cedar; rare; planted at corner of SR 103 and CR 200 N; BSUH 11203.

Pinaceae (Pine Family)

Picea abies (L.) Karst.: (a,*,+); Norway Spruce; rare; planted at corner of SR 103 and asphalt road into Unit 2; BSUH 10896.

Pinus banksiana Lambert: (c,*,+); Jack Pine; rare; Unit 2 woods south of asphalt road; these are being crowded out by the advancing deciduous forest; BSUH 10378.

Pinus resinosa Aiton: (a,*,+); Red Pine; infrequent; planted throughout property; BSUH 10862, 11623.

Pinus strobus L.: (a,*,+); Eastern or Northern White Pine; infrequent; planted throughout property; BSUH 10864.

Pinus sylvestris L.: (b,*,+); Scotch Pine; infrequent; planted throughout property and spreading; BSUH 11615.

Pinus virginiana Miller: (c,*,+); Virginia or Scrub Pine; rare; Unit 2 woods south of asphalt road; these are being crowded out by the advancing deciduous forest; BSUH 10384.

Taxaceae (Yew Family)

Taxus cuspidata Sieb. & Zucc.: (a,*,+); Japanese Yew; rare; planted next to building; BSUH 11566.

PHYLUM MAGNOLIOPSIDA
(Flowering Plants)

Acanthaceae (Acanthus Family)

Ruellia strepens L.: Smooth Ruellia; common; mesic woods especially along paths; BSUH 11242.

Aceraceae (Maple Family)

Acer negundo L.: Box-elder or Ash-leaved Maple; abundant; floodplain woods; BSUH 10460, 11040.

Acer nigrum Michx. f.: Black Maple; frequent; floodplain woods; BSUH 11597.

Acer platanoides L.: (b,*,+); Norway maple; abundant at several sites in Unit 2; mesic woods; BSUH 10464.

Acer platanoides L. cv. Schwedleri: (a,*,+); Purple Norway Maple; rare, one tree, apparently planted; Unit 2 field; BSUH 10660.

Acer rubrum L.: Red Maple; rare, one tree planted in Unit 4; BSUH 11444.

Acer saccharinum L.: Silver Maple; infrequent, some planted, some natural; floodplain woods and fields; BSUH 11019.

Acer saccharum Marshall: Sugar Maple; abundant; mesic woods; BSUH 10462, 10463.

Acoraceae (Sweet Flag Family)

Acorus calamus L.: (*,+); Sweet Flag; abundant in large dense colonies in localized sites; Units 1 and 4 fens and Unit 1 swales; BSUH 11006.

Agavaceae (Agave Family)

Yucca filamentosa L.: (b,*,+); Adam's Needle or Spanish Bayonet; infrequent but locally common; Units 1 and 2 dry fields; BSUH 11177.

Alismataceae (Water-Plantain Family)

Sagittaria latifolia Willd.: Common Arrowhead; infrequent; wet areas along the Little Blue River; BSUH 10734, 10902.

Amaranthaceae (Amaranth Family)

Amaranthus arenicola I.M. Johnst.: (*,+); Sandhill Amaranth; infrequent; disturbed areas; BSUH 10434.

Amaranthus powellii S. Wats.: (*,+); Amaranth; infrequent to common; disturbed areas; BSUH 11407.

Amaranthus retroflexus L.: (*,+); Redroot or Rough Pigweed or Green Amaranth; common to abundant; disturbed areas; BSUH 10723, 11175.

Froelichia gracilis (Hook.) Moq.: (*,+); Slender Cottonweed; locally abundant in the cindery area of Unit 1; BSUH 11438.

Anacardiaceae (Cashew Family)

Rhus glabra L.: Smooth Sumac; infrequent; several large colonies in fields; BSUH 11025.

Toxicodendron radicans (L.) Kuntze var. *negundo* (Greene) Reveal: (+); Common Poison Ivy; abundant; widespread; BSUH 11269.

Annonaceae (Custard-apple Family)

Asimina triloba (L.) Dunal: (+); Pawpaw; rare, one site with 12 individuals; Unit 2 along railroad track near Hillsboro Road; BSUH 11563, 11574.

Apiaceae (Carrot Family)

Angelica atropurpurea L.: Purplestem Angelica; infrequent; wet fields and river banks; BSUH 10993.

Chaerophyllum procumbens (L.) Crantz.: Spreading Chervil; infrequent; young woods in Unit 3; BSUH 10894, 11136.

Cicuta maculata L.: Common Water Hemlock; common; widespread in wet areas; BSUH 10467, 11254.

Conium maculatum L.: (*); Poison Hemlock; infrequent; roadsides; BSUH 10831.

Cryptotaenia canadensis (L.) DC.: Honewort; abundant; mesic and floodplain woods; BSUH 11003.

Daucus carota L.: (*); Wild Carrot or Queen Anne's Lace; abundant; fields; BSUH 10470, 10472.

Erigenia bulbosa (Michx.) Nutt.: (+); Harbinger of Spring; abundant; mesic woods; BSUH 10914.

Osmorhiza claytonii (Michx.) C.B. Clarke: Bland Sweet Cicely; abundant; mesic woods; BSUH 11154.

Osmorhiza longistylis (Torr.) DC.: Long-styled Sweet Cicely; abundant; mesic and floodplain woods; BSUH 10899.

Pastinaca sativa L.: (*); Wild Parsnip; abundant; fields, especially wet fields; BSUH 11262.

Sanicula canadensis L.: Canada Sanicle; common; open areas in woods and woods' edge; BSUH 11050, 11167.

Sanicula gregaria E. Bickn.: (+); Cluster Sanicle or Clustered Snakeroot; abundant; mesic and floodplain woods; BSUH 11116, 11126.

Sanicula trifoliata E. Bickn.: Beaked Sanicle; common; mesic woods; BSUH 11417, 11419.

Sium suave Walter: Water Parsnip; common; widespread in wet areas; BSUH 10707.

Thaspium trifoliatum (L.) A. Gray: Smooth Meadow Parsnip; infrequent; dry, open upland woods and wooded slopes; BSUH 10333, 10708.

Torilis arvensis (Hudson) Link: (*,+); Field Hedge Parsley; common; disturbed areas; BSUH 11060, 11183.

Apocynaceae (Dogbane Family)

Apocynum cannabinum L.: (+); Hemp Dogbane; common to abundant; fields; BSUH 11214.

Vinca minor L.: (a,*,+); Periwinkle; rare; planted next to building; BSUH 11507.

Araceae (Arum Family)

Arisaema triphyllum var. *triphyllum* (L.) Schott: Jack-in-the-pulpit; common; mesic woods; BSUH 10949, 11145.

Symplocarpus foetidus (L.) Nutt.: (+); Skunk Cabbage; infrequent although locally abundant at some sites; seeps, riverbanks and sedge meadows; BSUH 10875, 10877.

Araliaceae (Ginseng Family)

Panax quinquefolium L.: (+); American Ginseng; rare, two sites; mesic woods; BSUH 11073, 11352. [Watch List]

Aristolochiaceae (Birthwort Family)

Asarum canadense L.: Wild Ginger; abundant; mesic woods; BSUH 10952.

Asclepiadaceae (Milkweed Family)

Ampelamus albidus (Nutt.) Britton: (+); Sandvine; Blue Vine; common in fields and disturbed areas; BSUH 11401.

Asclepias incarnata L.: Swamp Milkweed; rare to infrequent; low wet areas in fields and Sweet Flag swales; BSUH 11082.

Asclepias syriaca L.: Common Milkweed; abundant; fields; BSUH 11174.

Asclepias verticillata L.: Whorled Milkweed; rare, two sites, but common at one site; dry open hillsides; BSUH 11458, 11472.

Asteraceae (Aster Family)

Achillea millefolium L.: (*); Common Yarrow; common; fields and roadsides; BSUH 11274.

Ambrosia artemisiifolia L.: Common ragweed; abundant; fields and disturbed areas; BSUH 10473, 10474.

Ambrosia trifida L.: Giant ragweed; abundant; widespread but especially in moist fields and floodplain woods; BSUH 10475, 10476.

Antennaria plantaginifolia (L.) Richardson: Plantain Pussytoes; rare; dry exposed slopes; BSUH 11306.

Arctium minus Schk.: (*,+); Common Burdock; common; fields, roadsides and wildlife fields; BSUH 10748, 10750.

Artemisia ludoviciana Nutt.: (b,*,+); White Sage; rare, one site with many plants; dry field; BSUH 10665, 11404.

Aster cordifolius L.: Common Blue Heart-leaved Aster; common; mesic woods; BSUH 11113.

Aster lanceolatus Willd. var. *simplex* (Willd.) Jones: Synonym—*Aster simplex* Willd.; Eastern Lined Aster; common; fields, meadows and wildlife plantings; BSUH 10477.

Aster lateriflorus (L.) Britton: (+); Goblet Aster;

common; mesic woods and wet fields; BSUH 10478.

Aster novae-angliae L.: New England Aster; abundant; fields and sedge meadows; BSUH 10480, 10481, 10482.

Aster pilosus Willd.: Awl Aster; abundant; fields; BSUH 10484, 10485.

Aster puniceus L.: Bristly Aster or Purple-stemmed Aster; common; sedge meadows, moist fields and riverbanks; BSUH 10487, 11109.

Aster sagittifolius Willd.: Arrow-leaved Aster; common; mesic woods; BSUH 10489, 10709.

Aster shortii Lindley: (+); Midwestern Blue Heart-leaved Aster; common; mesic woods; BSUH 10490, 10491.

Bidens cernua L.: Bur-marigold; infrequent; meadows; BSUH 10492, 10667.

Bidens comosa (A. Gray) Wieg.: (+); Strawstem Begger Tick; infrequent; meadows and riverbanks; BSUH 10493.

Bidens coronata (L.) Britton: Northern Tickseed Sunflower; rare, one site; sedge meadow; BSUH 10494.

Bidens frondosa L.: Devil's Begger Tick; infrequent; meadows; BSUH 10496, 10944.

Cacalia atriplicifolia L.: Pale Indian Plantain; rare; dry hilltop forest; BSUH 11070.

Carduus nutans L.: (*,+); Nodding or Musk Thistle; infrequent; fields with prairie plantings; BSUH 10753.

Centaurea maculosa Lam.: (*,+); Spotted Knapweed; infrequent; fields and waste areas; BSUH 10669.

Chrysanthemum leucanthemum L.: (*,+); Oxeye Daisy; abundant; fields; BSUH 11012.

Cichorium intybus L.: (*); Chicory; abundant; fields and roadsides; BSUH 11201, 11481.

Cirsium arvense var. *arvense* (L.) Scop.: (*); Canada Thistle; abundant; widespread; BSUH 10764, 11204.

Cirsium arvense (L.) Scop. var. *horridum* Wimmer & Graebner: (*); Canada Thistle; infrequent; fields; BSUH 11047.

Cirsium discolor (Muhl.) Sprengel.: Field Thistle; abundant; fields; BSUH 10497, 10692, 11522.

Conyza canadensis var. *canadensis* (L.) Cronq. (+); Horseweed; abundant; fields and roadsides; BSUH 10638.

Coreopsis grandiflora Hogg.: (*,+); Bigflower Tickseed; rare; Unit 1 field with prairie planting; BSUH 11029.

Coreopsis tinctoria Nutt.: (*,+); Plains Tickseed; rare; Unit 1 field with prairie planting; BSUH 10674.

Echinacea purpurea (L.) Minc.: (+); Purple Coneflower; rare; Unit 1 field with prairie planting; BSUH 10637.

Erechtites hieracifolia (L.) Raf.: (+); Fireweed; infrequent; roadsides; BSUH 10756.

Erigeron annuus (L.) Pers.: Annual Fleabane; abundant; fields and waste places; BSUH 11258, 11259.

Erigeron philadelphicus L.: Common or Philadelphia Fleabane or Philadelphia Daisy; abundant; mesic woods and fields; BSUH 11157, 11162.

Eupatorium altissimum L.: Tall Eupatorium; common; dry fields; BSUH 10498, 10499, 10500.

Eupatorium maculatum L.: Spotted Joe-Pye Weed; rare, one site; meadow; BSUH 10501.

Eupatorium perfoliatum L.: Boneset or Thoroughwort; abundant; moist fields and meadows; BSUH 10502, 10503, 10505.

Eupatorium purpureum L.: Purple-node Joe-Pye Weed; rare, one site; mowed strip under power lines in Unit 3; BSUH 11397.

Eupatorium rugosum Houttuyn: White Snakeroot; abundant; mesic woods; BSUH 10506, 10903.

Euthamia graminifolia (L.) Nutt.: Common Flat-topped Goldenrod; abundant; wet fields; BSUH 10507.

Galinsoga quadriradiata Ruiz & Pavon: (+); Common Quickweed; abundant; disturbed areas; BSUH 10671, 10673.

Helenium autumnale L.: Common Sneezeweed; common; wet fields, meadows and riverbanks; BSUH 10509.

Helianthus maximilianii Schrader: (*,+); Maximilian Sunflower; rare, one site; prairie planting in Unit 2; BSUH 10940.

Helianthus mollis Lamb.: (+); Ashy Sunflower; rare, one site with two colonies; prairie planting in Unit 2; BSUH 10650, 11405.

Helianthus tuberosus L.: Jerusalem Artichoke; common; fields and wood's edge; BSUH 10716.

Heliopsis helianthoides (L.): Sweet Sunflower Everlasting or False Sunflower; abundant; widespread in floodplain woods and wet fields; BSUH 10511, 10512.

Lactuca biennis (Minc.) Fern: Tall Blue Lettuce; common; mesic woods, woodland edges and fields; BSUH 11104.

Lactuca canadensis L.: Wild or Tall Lettuce; abundant; widespread; BSUH 11173.

Lactuca floridana (L.) Gaetner: Woodland Lettuce; common; mesic woods; BSUH 10661, 11693.

Lactuca saligna L.: (*); Willowleaf Lettuce; infrequent; fields and waste areas; BSUH 10643, 10654.

Lactuca serriola L.: (*); Prickly Lettuce; abundant; fields, especially in Units 3 and 4; BSUH 11453, 11454.

Matricaria matricarioides (Less.) Porter: (*,+); Pineapple Weed; common; roadsides; BSUH 11249.

Polymnia canadensis L.: (+); Pale-flowered or Small-flowered Leafcup; rare, one site; wood's edge in Unit 1; BSUH 11448.

Prenanthes altissima L.: Tall White Lettuce;

common to abundant although flowering plants rare; mesic woods; BSUH 10513.

Ratibida pinnata (Vent.) Barnard: Globular or Gray-headed Coneflower; infrequent; fields and prairie planting in Unit 2; BSUH 10662.

Rudbeckia fulgida var. *fulgida* Aiton: (+); Eastern or Orange Coneflower; rare; Unit 1 field with prairie planting; BSUH 10646. [Rare].

Rudbeckia hirta L. var. *pulcherrima* Farw.: Black-eyed Susan; abundant in sedge meadows of Unit 1; BSUH 10514, 11051.

Rudbeckia laciniata L.: Cutleaf, Tall or Green-headed Coneflower; common; widespread in floodplain woods; BSUH 10516, 10517, 10740.

Rudbeckia triloba var. *triloba* L.: (+); Three-leaved coneflower; infrequent; moist to wet areas in mesic woods and along river banks; BSUH 10518, 10519, 10946.

Senecio aureus L.: (+); Synonym—*Packera aurea* (L.) Love & Love; Heart-leaved Groundsel or Golden Ragwort; common; lowland moist to wet woods and seeps; BSUH 10876.

Senecio glabellus Poir.: Synonym—*Packera glabella* (Poir.) Jeffrey; Yellowtop; abundant; fields, disturbed areas and waste places; BSUH 11053, 11193.

Senecio obovatus Muhl.: Synonym—*Packera obovata* (Muhl.) Weber & Love; Running Groundsel or Round-leaved Ragwort; abundant; upland mesic woods; BSUH 10919, 10939.

Silphium integrifolium var. *integrifolium* Michx.: Prairie Rosinweed; rare, one site; prairie planting in Unit 2; BSUH 10726.

Silphium perfoliatum L.: Cup Plant; common; floodplain woods and wet meadows; BSUH 10724.

Solidago caesia L.: Axillary Goldenrod; abundant; mesic woods; BSUH 10521, 10522.

Solidago canadensis L. var. *canadensis*: Common Goldenrod; abundant; fields; BSUH 10718, 11644.

Solidago canadensis L. var. *scabra* T. & G.: Common Goldenrod; common; fields; BSUH 10523.

Solidago flexicaulis L.: (+); Zigzag Goldenrod; common; slopes in mesic woods; BSUH 10524.

Solidago gigantea Aiton: Smooth Goldenrod; common; Unit 1 field near sedge meadow; BSUH 11112.

Solidago nemoralis Aiton: (+); Gray Goldenrod; rare, one site with many plants; dry field in Unit 2; BSUH 10656, 11500.

Solidago patula Muhl.: Rough-leaved Goldenrod; rare, two site; Units 1 and 4 fens; BSUH 10526.

Sonchus asper (L.) Hill: (*); Prickly Sow Thistle; infrequent; roadsides and waste places; BSUH 10835.

Taraxacum officinale Weber: (+); Common Dandelion; abundant; widespread; BSUH 10866.

Tragopogon dubius Scop.: (*,+); Fistulous Goat's Beard; common; roadsides and fields; BSUH 11256.

Tragopogon pratensis L.: (*); Showy Goat's Beard; common; roadsides and fields; BSUH 11118, 11261.

Verbesina alternifolia (L.) Britton: Wingstem; abundant; widespread but most frequent in floodplain woods and wet fields; BSUH 10527, 10528.

Vernonia gigantea (Walter) Trel.: Tall Ironweed; abundant; fields; BSUH 10529.

Balsaminaceae (Touch-me-not Family)

Impatiens capensis Meerb.: Orange Touch-me-not (or Jewelweed); abundant; moist fields, floodplain woods and seeps; BSUH 10530, 10531.

Impatiens pallida Nutt.: Yellow Touch-me-not or Jewelweed; common; moist fields and woods; BSUH 10532, 10533, 10534.

Berberidaceae (Barberry Family)

Berberis thunbergii DC.: (*,+); Japanese Barberry; rare; mesic woods; BSUH 10535.

Podophyllum peltatum L.: May Apple; abundant; mesic woods; BSUH 11150.

Betulaceae (Birch Family)

Alnus glutinosa (L.) Gaertner: (*,+); Black or European Alder; rare, two sites; wood's edge; BSUH 10710.

Betula nigra L.: (*,+); River Birch; rare, one site with several trees; wood's edge; BSUH 11689.

Carpinus caroliniana Walter: Hornbeam, Blue Beech or Musclewood; abundant; mesic woods; BSUH 10741, 11090.

Ostrya virginiana (Miller) K. Koch: Hop-hornbeam or Ironwood; abundant; mesic woods; BSUH 11036.

Bignoniaceae (Trumpet Creeper Family)

Campsis radicans (L.) Seemann: Trumpet Creeper; infrequent; wood's edge and dry fields; BSUH 10664.

Catalpa speciosa Warder: (+); Northern Catalpa; rare, one site; field next to shooting range; BSUH 11450.

Boraginaceae (Borage Family)

Hackelia virginiana (L.) M. Johnston: (+); Stickseed or Beggar's Lice; common; fields and young woods; BSUH 11395, 11400, 11646.

Lithospermum arvense L.: (*,+); Synonym—*Buglossoides arvense* (L.) Johnst.; Corn Gromwell; rare, one site; disturbed area; BSUH 10931.

Brassicaceae (Mustard Family)

Alliaria petiolata (Bieb.) Cavara & Grande: (*,+); Garlic Mustard; abundant; widespread; BSUH 11140.

Arabis laevigata (Muhl.) Poiret: Rock Cress; infrequent; dry slope woods; BSUH 11580.

Barbarea vulgaris R. Brown: (*); Yellow Rocket; common; disturbed areas; BSUH 10936.

Brassica kaber (DC.) Wheeler: (*,+); Synonym—*Sinapis arvensis* L., Charlock; rare; roadsides; BSUH 10536.

Brassica nigra L.: (*,+); Black Mustard; common; fields (planted?); BSUH 11223, 11538.

Capsella bursa-pastoris (L.) Medikus: (*); Shepherd's Purse; frequent; roadsides and disturbed areas; BSUH 10937.

Cardamine concatenata (Michx.) O. Schwarz: Five-parted or Cut-leaf Toothwort; abundant; mesic woods; BSUH 10908.

Cardamine douglassii Britton: (+); Pink Spring Cress or Purple Cress; abundant; mesic woods; BSUH 10910.

Cardamine pensylvanica Muhl.: Pennsylvania Bittercress; rare; Little Blue River; BSUH 11134.

Cardamine rhomboidea (Pers.) DC.: Synonym—*Cardamine bulbosa* (Schreb. *ex* Muhl.) BSP; Spring Cress; infrequent; wet meadows; BSUH 10351.

Draba verna L.: (*,+); Whitlow Grass; infrequent; roadsides and disturbed areas; BSUH 10916.

Hesperis matronalis L.: (*,+); Dame's Rocket; rare, one site; bank of Big Blue River; BSUH 11526.

Iodanthus pinnatifidus (Michx.) Steudel.: (+); Purple Rocket; infrequent; moist meadows and riverbanks; BSUH 10970.

Lepidium campestre (L.) R. Brown: (*); Fieldcress or Field Peppergrass; infrequent; disturbed areas; BSUH 11120.

Lepidium virginicum L.: Poor-man's Pepper; infrequent; disturbed areas; BSUH 11532.

Rorippa nasturtium-aquaticum (L.) Hayek.: (*,+); Synonym—*Nasturtium officinale* R. Br.; Water Cress; infrequent; Big Blue River; BSUH 11475, 11484.

Sisymbrium loeselii L.: (*,+); Tall Hedge Mustard; abundant; fields and disturbed areas; BSUH 11032.

Thlaspi arvense L.: (*); Field Pennycress; infrequent; disturbed areas; BSUH 10857, 10880.

Caesalpiniaceae (Caesalpinia Family)

Cercis canadensis L.: Redbud; infrequent; woodland edges; BSUH 10881.

Chamaecrista fasciculata (Michx.) Greene: (+); Partridge Pea; rare, one site; prairie planting; BSUH 10469.

Gleditsia triacanthos L.: (+); Honey Locust; common; floodplain woods and woodland edges; BSUH 10537.

Gleditsia triacanthos f. *inermis* (L.) Zabel: (b,+); Thornless Honey Locust; abundant in Unit 2 near old village site; BSUH 11424.

Gymnocladus dioica (L.) K. Koch: (+); Kentucky Coffeetree; infrequent; mesic woods and planted; BSUH 10666.

Campanulaceae (Bellflower Family)

Campanula americana L.: (+); Tall Bellflower; abundant; mesic woods; BSUH 10539, 10540, 10541.

Campanula rapunculoides L.: (*,+); Creeping or Rover Bellflower; rare; field and building sites; BSUH 10700.

Lobelia inflata L.: Indian Tobacco; infrequent; wood's edge; BSUH 11415.

Lobelia siphilitica L.: Great Lobelia; infrequent; wet fields and streambanks; BSUH 10542, 10543.

Cannabaceae (Indian Hemp Family)

Humulus lupulus L. var. *lupuloides* E. Small: Hops; common; floodplain woods, wet meadows and fields; BSUH 10545, 10649, 10729, 10730, 10731.

Caprifoliaceae (Honeysuckle Family)

Lonicera × *bella* Zabel: (b,+); Honeysuckle; frequent; floodplain woods; BSUH 10999.

Lonicera japonica Thunb.: (*,+); Japanese Honeysuckle; common in Units 2 and 3; BSUH 11494.

Lonicera maackii (Rupr.) Maxim: (*,+); Amur Honeysuckle; abundant; fields and young woods; BSUH 11125, 11139.

Lonicera morrowii A. Gray: (*,+); Morrow Honeysuckle; frequent; floodplain woods; BSUH 11001.

Lonicera prolifera (Kirch.) Rehder: Grape Honeysuckle; rare, one colony; dry hillside in successional woods in Unit 3; BSUH 11560, 11564.

Lonicera tatarica L.: (*,+); Tartarian Honeysuckle; rare, one bush; field; BSUH 11456.

Sambucus canadensis L.: Common Elder; common; floodplain woods and meadows; BSUH 11210.

Viburnum acerifolium L.: Dockmackie or Flowering Maple; infrequent; mesic woods; BSUH 10994.

Viburnum lentago L.: Sheepberry or Nannyberry; rare; mesic woods; BSUH 10897, 11562.

Viburnum opulus var. *opulus* L.: (*,+); Guelder Rose; infrequent; fields and wood's edge; BSUH 10738, 10849.

Viburnum prunifolium L.: Black Haw; common; mesic woods; BSUH 11561, 11603.

Weigela florida (Bunge) A. DC. var. *nusta*: (a,*,+); Old-fashioned Weigela; rare, one site; next to asphalt road in Unit 2; BSUH 11537.

Caryophyllaceae (Pink Family)

Arenaria serpyllifolia L.: (*); Thyme-leaved Sandwort; infrequent; disturbed areas; BSUH 11164.

Cerastium vulgatum L.: (*,+); Mouse-ear Chickweed; common; disturbed areas, roadsides and waste places; BSUH 11165, 11452.

Dianthus armeria L.: (*); Deptford Pink; common; fields; BSUH 11042, 11244.

Holosteum umbellatum L.: (*,+); Jagged Chickweed; disturbed areas; BSUH 10861.

Saponaria officinalis L.: (*); Soapwort or Bouncing Bet; infrequent to common; widespread; BSUH 10547, 10659.

Silene antirrhina L.: (+); Sleepy Catchfly; rare, one site with many plants; cindery area of Unit 1; BSUH 11620.

Silene latifolia Poiret: (*,+); White Campion; abundant; fields; BSUH 11268.

Silene stellata (L.) Aiton f.: (+); Starry Campion; infrequent; mesic woods; BSUH 11077.

Silene virginica L.: Fire Pink; infrequent; sunny wooded slopes in mesic woods; BSUH 11234.

Stellaria media (L.) Villars: (*); Common Chickweed; abundant; widespread in young woods, fields, roadsides and disturbed sites; BSUH 10867.

Stellaria pubera Michx.: Star or Great Chickweed; common; mesic woods; BSUH 10922.

Celastraceae (Staff-tree Family)

Celastrus orbiculatus Thunb.: (b,*,+); Oriental Bittersweet; rare, one large colony in Unit 2; field; BSUH 10548, 10845.

Celastrus scandens L.: American Bittersweet; rare, one colony; edge of mesic woods; BSUH 11271.

Euonymus alatus (Thunb.) Siebold.: (a,*,+); Winged Burning Bush; rare; planted next to office; BSUH 11492.

Euonymus atropurpureus Jacq.: Wahoo; infrequent; floodplain woods; BSUH 11426.

Euonymus fortunei (Turcz.) Hand.-Mazz.: (a,*,+); Wintercreeper; rare; planted near building and in woods near Unit 4 fen; BSUH 11411.

Euonymus obovatus Nutt.: Running Strawberry Bush; common on hilltop forest of Unit 2; BSUH 11616.

Ceratophyllaceae (Hornwort Family)

Ceratophyllum demersum L.: (+); Hornwort or Coontail; frequent; Big Blue River; BSUH 11670.

Chenopodiaceae (Goosefoot Family)

Chenopodium album L.: (+); Lamb's Quarters or Pigweed; abundant; disturbed areas; BSUH 10754.

Clusiaceae (Mangosteen Family)

Hypericum perforatum L.: (*,+); Common St. John's Wort; infrequent; moist fields and meadows; BSUH 10696.

Hypericum punctatum Lam.: Spotted St. John's Wort; infrequent; eroding, moist bank along Little Blue River; BSUH 10550.

Commelinaceae (Spiderwort Family)

Commelina communis L.: (*,+); Common Day Flower; infrequent; open mesic woods and river bank; BSUH 10743, 11102.

Tradescantia subaspera Ker Gawler: (+); Wide-leaved Spiderwort; infrequent, though colonies large; woodland edges and floodplain woods; BSUH 11534, 11555.

Tradescantia virginiana L.: Virginia Spiderwort; rare, two sites; sunny wooded slopes; BSUH 10850.

Convolvulaceae (Morning-glory Family)

Calystegia sepium (L.) R. Br.: Hedge Bindweed; common; fields; BSUH 10549, 10551.

Convolvulus arvensis L.: (*,+); Field Bindweed; frequent; fields and roadsides; BSUH 11260.

Ipomoea hederacea Jacq.: (*,+); Ivy-leaved Morning Glory; infrequent; fields; BSUH 10552.

Ipomoea pandurata (L.) G. Meyer: Wild Potato; infrequent to frequent, especially in Unit 1 fields; BSUH 11402.

Ipomoea purpurea (L.) Roth.: (*,+); Common Morning Glory; infrequent; fields; BSUH 10806.

Cornaceae (Dogwood Family)

Cornus alternifolia L. f.: Pagoda Dogwood; rare; wooded ravines and seeps; BSUH 11094.

Cornus amomum Miller var. *schuetzeana* (C.A. Miller) Rickett: Knob-styled Dogwood; abundant; widespread in moist soil; BSUH 11288.

Cornus drummondii C.A. Meyer: (+); Rough-leaved Dogwood; abundant; fields and wood's edge; BSUH 11216.

Cornus florida L.: Flowering Dogwood; infrequent to common; mesic woods and dry hilltops; BSUH 11149.

Cornus racemosa Lam.: (+); Northern Swamp Dogwood; infrequent; wood's edge; BSUH 11286.

Nyssa sylvatica Marshall: (+); Black Tupelo or Black Gum; rare, several sites with only one tree; BSUH 10713.

Crassulaceae (Stonecrop Family)

Sedum sarmentosum Bunge: (a,*,+); Stonecrop; rare, one site; planted near building; BSUH 11510.

Sedum ternatum Michx.: (+); Stonecrop (White); frequent; wet mesic woods and floodplain woods; BSUH 11152.

Cucurbitaceae (Gourd Family)

Echinocystis lobata (Michx.) T.& G.: (+); Balsam Apple; Wild Cucumber; infrequent; wet fields and waste places; BSUH 10648.

Cuscutaceae (Dodder Family)

Cuscuta gronovii Willd.: Common Dodder; infrequent; parasitic on plants in wet fields; BSUH 10553, 10674.

Cyperaceae (Sedge Family)

Carex aggregata Mackenzie: Synonym—*Carex sparganioides* Muhl. var. *aggregata* (Mackenzie) Gleason; Sedge; infrequent; woods and thickets; BSUH 10804, 11325, 11393.

Carex albicans Willd.: (+); Sedge; dry upland woods; infrequent; BSUH 11310.

Carex albursina Sheldon: Sedge; common; moist areas of mesic woods and alluvial plains; BSUH 11324.

Carex atherodes Sprengel: (+); Sedge; rare, one very large colony; moist field/sedge meadow; (this only the 5th known collection of this species in the state; BSUH 11376, 11377, 11392.

Carex blanda Dewey: Sedge; infrequent; mesic woods; BSUH 11293.

Carex careyana Torr.: (+); Sedge; infrequent; mesic woods (moist ravine hillsides); BSUH 10980, 11323.

Carex communis Bailey: Sedge; common; moist hills in mesic woods; BSUH 11297, 11390.

Carex complanata Torr. & Hook var. *hirsuta* (L. Bailey) Gleason: (+); Sedge; infrequent; mesic woods; BSUH 11313.

Carex conjuncta Muhl.: (+); Sedge; common; widespread in moist field and riverbanks; BSUH 11370, 11372.

Carex cristatella Britton: Sedge; common; moist fields and sedge meadows; BSUH 10786, 11381.

Carex davisii Schwein & Torr.: Sedge; abundant; widespread; BSUH 10785, 10991, 10992, 10995, 11380.

Carex emoryi Dewey: (+); Sedge; common; sedge meadows; BSUH 10780.

Carex frankii Kunth.: Sedge; infrequent; alluvial plains and moist meadows and fields; BSUH 11347, 11674.

Carex gracillima Schwein: Sedge; rare; alluvial plain; BSUH 11296.

Carex granularis Muhl.: Sedge; common; sedge meadows and wet fields; BSUH 10792, 11320.

Carex gravida var. *gravida* L. Bailey: (+); Sedge; rare; moist field; (this species is out of its normal range; it is more northern and western); BSUH 10803.

Carex grayi Carey: Sedge; rare; vernal pool in mesic woods; BSUH 11656.

Carex grisea Wahlenb.: (+); Synonym—*Carex amphibola* Steudel; Sedge; infrequent; creek bank and alluvial plain in mesic woods; BSUH 11299.

Carex hirtifolia Mackenzie: Sedge; infrequent; mesic woods; BSUH 11295.

Carex hitchcockiana Dewey: Sedge; rare; mesic woods; BSUH 11307.

Carex hystericina Muhl.: Sedge; common; sedge meadows; BSUH 10986, 10987, 11316.

Carex jamesii Schwein.: Sedge; infrequent; mesic woods; BSUH 11294.

Carex laevivaginata (Kuk.) Mackenzie: Sedge; common; sedge meadow, edge of river and alluvial plain; BSUH 10989, 10990, 10996.

Carex laxiculmis Schwein: Sedge; infrequent; mesic woods; BSUH 10783.

Carex laxiflora Lam.: Sedge; infrequent; wooded slopes; BSUH 11321.

Carex lurida Wahlenb.: Sedge; frequent to common; sedge meadow; BSUH 10789, 10791.

Carex mesochorea Mackenzie: (+); Synonym—*Carex cephalophora* Muhl. var. *mesochorea* (Mackenzie) Gleason; Sedge; infrequent; in crack of asphalt and dry fields; BSUH 10806.

Carex molesta Bright: (+); Sedge; infrequent; low wet fields; BSUH 11368, 11676.

Carex normalis Mackenzie: (+); Sedge; frequent; wood's edge and field with prairie plantings; BSUH 11371, 11682.

Carex pellita Muhl.: (+); Sedge; rare; fen in Unit 1; BSUH 11311.

Carex pensylvanica Lam.: Sedge; infrequent; dry hilltop forest; BSUH 11308.

Carex prasina Wahlenb.: (+); Sedge; infrequent; wet woods and streambanks; BSUH 11322, 11686.

Carex radiata (Wahlenb.) Small: (+); Sedge; abundant; moist woods and wet field; BSUH 11300.

Carex rosea Schk.: Sedge; common; rich mesic woods; BSUH 11302.

Carex shortiana Dewey: Sedge; common; wet fields; BSUH 11309, 11369.

Carex sparganioides var. *sparganioides* Muhl.: Sedge; infrequent; mesic woods; BSUH 10981, 11298.

Carex sterilis Willd.: (+); Sedge; infrequent; sedge meadow; BSUH 11317.

Carex stipata Muhl.: Sedge; abundant; low wet fields; BSUH 11319, 11394.

Carex stricta Lam.: Sedge; infrequent; several large colonies; sedge meadows; BSUH 10962.

Carex suberecta (Olney) Britton: (+); Sedge; infrequent; sedge meadow; BSUH 10800, 11315.

Carex tribuloides Wahlenb.: Sedge; infrequent; vernal pool in mesic woods and wet fields; BSUH 10796, 11642.

Carex trichocarpa Muhl.: Sedge; rare, one large colony; sedge meadow; BSUH 11314.

Carex vulpinoidea var. *vulpinoidea* Michx.: Sedge; common; sedge meadow and wet fields; BSUH 10793, 10795.

Carex woodii Dewey: (+); Sedge; infrequent; mesic woods; BSUH 10361.

Cyperus esculentus L.: (+); Field or Yellow Nutsedge; common; disturbed areas; BSUH 11640, 11710.

Cyperus strigosus L.: (+); Long-scaled Nutsedge; infrequent; disturbed areas; BSUH 11647.

Eleocharis acicularis (L.) Roemer & Schultes: (+); Needle Spike Rush; rare, one site; low wet disturbed area; BSUH 11618.

Eleocharis erythropoda Steud.: (+); Red-rooted

Spike Rush; rare, one site; wet field/meadow; BSUH 11351.

Eleocharis obtusa (Willd.) Schult.: Blunt Spike Rush; rare, one site; low wet disturbed area; BSUH 11619.

Eleocharis palustris (L.) Roem. & Schult. var. *major* Sond.: (+); Great Spike Rush; infrequent but locally abundant; wet fields and sedge meadow; BSUH 11350.

Scirpus atrovirens Willd.: Dark Green Bulrush; common; seeps, sedge meadows, ditches and wet fields; BSUH 11658, 11659.

Scirpus georgianus R.M. Harper: (+); Bristleless Dark Green Bulrush; rare to infrequent; wet fields and sedge meadows; BSUH 11391.

Scirpus hattorianus Willd.: (+); Early Dark Green Bulrush; common; seeps, sedge meadows, ditches and wet fields; BSUH 11344, 11345.

Scirpus pendulus Muhl.: (+); Red Bulrush; rare, one site; moist field; BSUH 10798.

Scirpus validus Vahl.: (+); Great or Softstem Bulrush; rare, one site; sedge meadow; BSUH 11346.

Dipsacaceae (Teasel Family)

Dipsacus sylvestris Hudson: (*,+); Teasel; common to abundant; wet fields; BSUH 10554, 10555.

Elaeagnaceae (Oleaster Family)

Elaeagnus umbellata Thunb.: (*,+); Autumn Olive; abundant; widespread in old fields and openings in woods; BSUH 11143.

Euphorbiaceae (Spurge Family)

Acalypha rhomboidea Raf.: Synonym—*Acalypha virginica* L. var. *rhomboidea* (Raf.) Coperr.; Rhombic Copperleaf or Three-seeded Mercury; infrequent; fields, roadsides and waste places; BSUH 11649.

Euphorbia dentata Michx.: Synonym—*Poinsettia dentata* (Michx.) Small (this is the broad-leaved form); Toothed Spurge; infrequent; roadsides; BSUH 10658, 10728.

Euphorbia dentata Michx.: (+); Synonyms—*Euphorbia dentata* var. *cuphosperma* Engelm; *E. cuphosperma* (this is the narrow-leaved form); Toothed Spurge; rare; growing in cracks in asphalt road of Unit 2; BSUH 10657.

Euphorbia maculata L.: Synonyms—*Chamaesyce maculata* (L.) Small, *Euphorbia supina* Raf.; Milk Purslane or Spotted Spurge; abundant; roadsides, dry fields and cracks in asphalt; BSUH 10676, 10905.

Euphorbia nutans Lagasca: (+); Synonym—*Chamaesyce nutans* (Lag.) Small; Eyebane; abundant; roadsides, dry fields and cracks in asphalt; BSUH 11101, 11521.

Fabaceae (Pea or Bean Family)

Amphicarpaea bracteata (L.) Fern.: (+); Hog Peanut; infrequent, common along the bank of the Little Blue River; BSUH 10652, 10749, 10942.

Coronilla varia L.: (*,+); Crown Vetch; common; fields and roadsides (planted?); BSUH 10560, 10561.

Desmodium canadense (L.) DC.: Canadian Tick Trefoil; infrequent; moist fields near sedge meadows; BSUH 11434.

Desmodium glutinosum (Muhl.) A. Wood: Cluster-leaf Tick Trefoil; infrequent; mesic woods; BSUH 11075.

Lespedeza bicolor Turcz.: (a,*,+); Bicolor Lespedeza; rare; several plants on a fence row near maintenance barn in Unit 1; BSUH 10717.

Lotus corniculatus L.: (*,+); Birdsfoot Trefoil; common to abundant; field and roadsides Unit 1; BSUH 11246.

Medicago lupulina L.: (*); Black Medick; abundant; disturbed areas, roadsides, fields and waste places; BSUH 11163.

Medicago sativa L.: (*); Alfalfa; common; fields (planted?); BSUH 11200.

Melilotus alba Medikus: (*); White Sweet Clover; frequent; roadsides, fields and waste places; BSUH 11213.

Melilotus officinalis (L.) Pallas: (*); Yellow Sweet Clover; abundant; roadsides, fields and waste places; BSUH 10837.

Robinia pseudoacacia L.: (b); Black Locust; abundant; planted in grooves in fields; BSUH 11023, 11550.

Trifolium campestre Schreber: (*,+); Pinnate Hop Clover; infrequent to common; fields; BSUH 11275.

Trifolium hybridum L.: (*,+); Alsike Clover; common; roadsides and fields; BSUH 11250.

Trifolium pratense L.: (*,+); Red Clover; abundant; roadsides and fields; BSUH 10563, 10564, 10836.

Trifolium repens L.: (*,+); White Clover; common; roadsides, fields and lawns; BSUH 10670, 10839.

Vicia cracca L.: (*,+); Bird (Cow) Vetch; rare, one site; field; BSUH 10668.

Fagaceae (Beech Family)

Fagus grandifolia Ehrh.: American Beech; common; mesic woods; BSUH 10565.

Quercus alba L.: White Oak; abundant; mesic woods; BSUH 10566.

Quercus imbricaria Michx.: (a); Shingle Oak; rare, one site; field; BSUH 11171, 11172.

Quercus macrocarpa Michx.: Bur Oak; rare; mesic woods and floodplain woods; BSUH 10768, 10769.

Quercus muehlenbergii Engelm: Yellow or Chinquapin Oak; common; mesic woods especially along rivers on wooded slopes; BSUH 10567.

Quercus palustris Muenchh.: Pin Oak; rare (planted?); fields; BSUH 11027.

Quercus rubra L.: Northern Red Oak; abundant; mesic woods; BSUH 10766, 11577.

Quercus velutina Lam.: Black Oak; infrequent; dry hilltop forest; BSUH 11095.

Fumariaceae (Fumitory Family)

Dicentra canadensis (Goldie) Walp.: (z,+); Squirrel Corn; rare; ravine slope near Little Blue River; BSUH 10279.

Dicentra cucullaria (L.) Bernh.: Dutchman's Breeches; abundant; mesic woods especially on wooded slopes; BSUH 10945.

Gentianaceae (Gentian Family)

Frasera caroliniensis Walter: (+); American Columbo; rare, one large colony; dry upland woods; BSUH 11096, 11572.

Geraniaceae (Geranium Family)

Geranium maculatum L.: Wild Geranium; abundant; mesic woods; BSUH 10901, 11147.

Geranium pusillum L.: (*,+); Small-flowered Crane's-bill; rare; roadsides; BSUH 11460.

Grossulariaceae (Gooseberry Family)

Ribes americanum Miller: (+); Eastern Black Currant; rare, one colony in Unit 3; wet thicket; BSUH 11476.

Ribes cynosbati L.: Dogberry; common to abundant; mesic woods; BSUH 10887.

Ribes missouriense Nutt.: Missouri Gooseberry; infrequent; mesic woods; BSUH 11583.

Haloragaceae (Water Milfoil Family)

Myriophyllum sp.: (+); Water Milfoil; infrequent; Big Blue River; BSUH 11668.

Hamamelidaceae (Witch Hazel Family)

Liquidambar styraciflua L.: (a,+); Sweet Gum; rare, two sites; fields; BSUH 11455.

Hippocastanaceae (Horse-chestnut Family)

Aesculus glabra Willd.: Ohio Buckeye; abundant; floodplain woods and occasionally in mesic woods; BSUH 10950.

Hydrangeaceae (Hydrangea Family)

Hydrangea arborescens L.: (+); American Hydrangea; common; wooded slopes with seeps; BSUH 10569, 10695, 10777.

Hydrophyllaceae (Waterleaf Family)

Hydrophyllum appendiculatum Michx.: (+); Biennial Waterleaf; abundant; mesic woods; BSUH 11148.

Hydrophyllum macrophyllum Nutt.: (+); Hairy Waterleaf; abundant; mesic woods; BSUH 10328, 10362, 11098.

Hydrophyllum virginianum L.: Eastern Waterleaf; infrequent; floodplain woods of Unit 3; BSUH 11552.

Phacelia purshii Buckley: (+); Miami Mist; infrequent; floodplain woods Unit 3; BSUH 10442.

Iridaceae (Iris Family)

Iris germanica L.: (*,+); German Iris; infrequent; fields; BSUH 10848.

Iris pseudacorus L.: (*,+); Water Flag or Yellow Flag; rare; artificial pond near office; BSUH 11431.

Iris virginica L. var. *shrevei* (Small) E. Anderson: Southern Blue Flag; frequent; wet areas in meadows and floodplain woods; BSUH 10971.

Sisyrinchium angustifolium Miller: (+); Blue-eyed Grass; infrequent; wet meadows; BSUH 10963.

Juglandaceae (Walnut Family)

Carya cordiformis (Wangenh.) K. Koch: Bitternut Hickory; abundant; mesic woods; BSUH 11058.

Carya glabra (Miller) Sweet: (+); Pignut Hickory; common; mesic woods, especially dry hilltops; BSUH 11099.

Carya ovata (Miller) K. Koch: Shagbark Hickory; abundant; mesic woods; BSUH 11160.

Juglans cinerea L.: (+); Butternut; rare, two sites; floodplain woods and floodplain woods; BSUH 11578.

Juglans nigra L.: Black Walnut; abundant; mesic and floodplain woods; BSUH 11169.

Juncaceae (Rush Family)

Juncus tenuis Willd. var. *dudleyi* (Wieg.) F.S. Herm.: (+); Synonym—*Juncus dudleyi* Wiegand; Path Rush or Dudley's Rush; common to abundant; sedge meadows and wet areas; BSUH 10976, 11653.

Juncus tenuis var. *tenuis* Willd.: Path Rush; common; fields, meadows, and paths; BSUH 10802.

Juncus torreyi Coville: Rush; infrequent to frequent; ditches, sedge meadows and wet fields; BSUH 11348, 11355, 11625, 11629, 11680.

Luzula multiflora (Retz.) Lej.: (+); Common Wood Rush; infrequent; dry hilltop woods; BSUH 11312, 11389.

Lamiaceae (Mint Family)

Agastache nepetoides (L.) Kuntze: Catnip Giant Hyssop; infrequent; railroad bank and wooded fields; BSUH 10571.

Blephilia hirsuta (Pursh.) Benth.: Wood Mint or Pagoda Plant; infrequent; mesic woods and floodplain woods; BSUH 11556.

Glechoma hederacea L.: (*,+); Gill-over-the-ground; abundant; widespread; BSUH 10909.

Lamium amplexicaule L.: (*); Henbit; abundant; disturbed areas; BSUH 10869.

Lamium purpureum L.: (*); Red Dead Nettle; abundant; disturbed areas; BSUH 10871.

Leonurus cardiaca L.: (*); Motherwort or Lion's Tail; common (in large colonies); fields and waste areas; BSUH 11206.

Lycopus americanus Muhl.: American Water Horehound; common; wet fields and meadows; BSUH 10573, 11089.

Lycopus uniflorus Michx.: Northern Water Horehound; infrequent, though locally common in Sweet Flag swales; Sweet Flag swales and wet fields; BSUH 10468, 10559, 11557.

Mentha arvensis L.: Wild or Field Mint; common; wet fields and meadows; BSUH 11097.

Mentha × *gentilis* L.: (+); Red or Scotch Mint; infrequent; sedge meadow; BSUH 10574.

Monarda clinopodia L.: (+); Basil Bee-balm; infrequent but often in large colonies; floodplain woods and riverbanks; BSUH 10678, 10684, 11464.

Nepeta cataria L.: (*); Catnip; abundant; widespread; BSUH 10704, 10778.

Physostegia virginiana (L.) Benth.: (+); Obedience; rare, two colonies; floodplain woods and riverbank; BSUH 10575, 11697.

Prunella vulgaris L.: Sealheal; abundant; moist fields; BSUH 10576, 10694.

Pycnanthemum virginianum (L.) Druand. & B.D. Jackson: Mountain Mint; infrequent; sedge meadows; BSUH 10577.

Scutellaria incana Biehler: Downy Skullcap; infrequent; mesic woods; BSUH 10691, 11078.

Scutellaria lateriflora L.: (+); Skullcap (Maddog skullcap); infrequent; wet meadows, stream banks and Sweet Flag swales; BSUH 10579.

Scutellaria ovata Hill var. *versicolor* (Nutt.) Fern.: (+); Forest Skullcap; rare, one site; mesic woods near an opening; BSUH 10690.

Stachys tenuifolia Willd.: Smooth Hedge Nettle; abundant; wet meadows, floodplain woods and Sweet Flag swales; BSUH 10580.

Synandra hispidula (Michx.) Britton: (z,+); Synandra or Gyandotte-beauty; rare; mesic woods; BSUH 10863. [Watch List]

Teucrium canadense L. var. *virginicum* (L.) Eaton: American Germander; common; open mesic woods and wet meadows; BSUH 11079.

Lauraceae (Laurel Family)

Lindera benzoin (L.) Blume: Spicebush; infrequent; mesic woods; BSUH 11068.

Sassafras albidum (Nutt.) Nees: (+); Sassafras; rare; two sites with twelve stems at one site; BSUH 11208.

Lemnaceae (Duckweed Family)

Lemna minor L.: (+); Lesser Duckweed; infrequent; Little Blue River; BSUH 11093.

Wolffia papulifera C. Thompson: (+); Water Meal; infrequent; Little Blue River; BSUH 11091.

Liliaceae (Lily Family)

Allium canadense L.: (+); Onion or Wild Garlic; common; fields and floodplain woods; BSUH 11230.

Allium tricoccum var. *tricoccum* Aiton: Ramps; abundant; mesic woods; BSUH 11030.

Allium vineale L.: (*); Field Garlic or Scallions; common; fields; BSUH 11220.

Asparagus officinalis L.: (a,*,+); Asparagus; rare, two sites (planted?); fields and woods' edge; BSUH 11017.

Camassia scilloides (Raf.) Cory: Wild Hyacinth; abundant; moist, shallow sloping areas in mesic woods; BSUH 11146.

Convallaria majalis L.: (*,+); Lily of the Valley; rare, two sites (planted?); mesic woods; BSUH 10947, 11581.

Erythronium albidum Nutt.: (+); White Trout Lily; rare, one site with many plants; mesic woods; BSUH 11513.

Erythronium americanum Ker Gawler: Yellow Trout Lily or Fawn Lily; common; mesic woods; BSUH 10961.

Hemerocallis fulva L.: (b,*,+); Day Lily; common; old building sites, hill slopes, fields and roadsides; BSUH 11185.

Lilium michiganense Farw.: (+); Michigan Lily; rare, one site; mesic woods (these did not flower during this study); BSUH 11541.

Narcissus poeticus L.: (b,*,+); Poet's Narcissus; infrequent; old building sites now in mesic woods and fields; BSUH 10934.

Narcissus pseudonarcissus L.: (b,*,+); Daffodil; infrequent; old building sites now in mesic woods and fields; BSUH 10858.

Ornithogalum umbellatum L.: (b,*,+); Star of Bethlehem; rare; floodplain woods in Unit 1 (planted?); BSUH 11158.

Polygonatum biflorum (Walter) Elliott: (+); Smooth Solomon's Seal; abundant; mesic woods; BSUH 11014.

Polygonatum biflorum (Walter) Elliott var. *commutatum* (Schultes f.) Morong.: (+); Great Solomon's Seal; common; mesic woods; (see Voss (1972) for a discussion of this variety); BSUH 11015.

Polygonatum pubescens (Willd.) Pursh.: Downy Solomon's Seal; infrequent; mesic woods; BSUH 11416.

Smilacina racemosa (L.) Desf.: Synonym—*Maianthemum racemosus* (L.) Link; False Solomon's Seal or Feathery Solomon's Plume; infrequent; mesic woods; BSUH 11005.

Smilacina stellata (L.) Desf.: (+); Synonym—*Maianthemum stellatum* (L.) Link; Star-flowered

False Solomon's Seal or Starry Solomon's Plume; rare; woodland seep; BSUH 10299, 11695.

Trillium flexipes Raf.: (+); Bent Trillium; common; mesic woods; BSUH 10889.

Trillium recurvatum Beck.: Prairie Trillium; abundant; mesic woods; BSUH 10923.

Trillium sessile L.: Toadshade; common; mesic woods; BSUH 10926.

Trillium sessile var. *luteum* L.: Toadshade; infrequent; mesic woods; (this variety is recognized by Deam, 1940); BSUH 10376.

Uvularia grandiflora T.E. Smith: Bellwort; common; mesic woods; BSUH 10918, 10943.

Veratrum woodii Robbins: (+); Synonym—*Melanthium woodii* (Robbins) Bodkin; Wood's False Hellebore; rare, one plant; mesic woods; BSUH 11280.

Limnanthaceae (Meadow-foam Family)

Floerkea proserpinacoides Willd.: False Mermaid; rare, one site; riverbank; BSUH 10883.

Magnoliaceae (Magnolia Family)

Liriodendron tulipifera L.: Tuliptree; abundant; mesic woods; BSUH 10581, 10843, 11595.

Malvaceae (Mallow Family)

Abutilon theophrasti Medikus: (*); Velvetleaf or Pie Marker; common; disturbed areas; BSUH 11044.

Hibiscus trionum L.: (*); Flower of an Hour; infrequent; disturbed areas; BSUH 11540.

Malva neglecta Wallr.: (*); Common Mallow or Cheeses; infrequent; disturbed areas and waste places; BSUH 10841.

Menispermaceae (Moonseed Family)

Menispermum canadense L.: Moonseed; infrequent; woods; BSUH 11187, 11194.

Mimosaceae (Mimosa Family)

Desmanthus illinoensis (Michx.) MacMillan: (b,+); Bundleflower or Prairie Mimosa; infrequent; in prairie planted fields; BSUH 10645, 10759.

Molluginaceae (Carpetweed Family)

Mollugo verticillata L.: (*,+); Carpetweed; infrequent; disturbed areas and cindery area; BSUH 10679, 11409.

Monotropaceae (Indian Pipe Family)

Monotropa uniflora L.: (+); Indian Pipe; infrequent; mesic woods; BSUH 11103.

Moraceae (Mulberry Family)

Maclura pomifera (Raf.) C.K. Schneider: (*); Osage-orange; common (especially in Unit 4); floodplain woods and woods' edge; BSUH 11245, 11267.

Morus alba L.: (*); White Mulberry; abundant; wood's edge and fields; BSUH 10582, 10853.

Morus rubra L.: Red Mulberry; infrequent; mesic woods; BSUH 11111.

Nyctaginaceae (Four-O'Clock Family)

Mirabilis nyctaginea (Michx.) MacMillan: (*,+); Umbrella Wort; rare, one site; one field with prairie plantings; BSUH 11525.

Oleaceae (Olive Family)

Forsythia × intermedia Zabel: (a,*,+); Border Forsythia; rare; planted next to building; BSUH 11504.

Fraxinus americana L.: White Ash; common; mesic woods and floodplain woods; BSUH 10736.

Fraxinus nigra Marshall: Black Ash; infrequent; floodplain woods; BSUH 11694.

Fraxinus pennsylvanica Marshall: Green Ash; common; floodplain woods; BSUH 11062.

Fraxinus quadrangulata Michx.: (+); Blue Ash; common; mesic woods; BSUH 10584, 11188.

Ligustrum vulgare L.: (b,*,+); Common Privet; infrequent, though locally abundant at one site in Unit 2; mesic woods; BSUH 11285.

Syringa vulgaris L.: (b,*,+); Common Lilac; common in Unit 2 field and woods south of asphalt road; BSUH 11354, 11593, 11605.

Onagraceae (Evening Primrose Family)

Circaea lutetiana var. *canadensis* L.: Synonym—*Circaea quadrisulcata* (Maxim.) Franch. & Sav.; Common Enchanter's Nightshade; abundant; mesic woods; BSUH 10772.

Epilobium ciliatum Raf.: (+); American Willow Herb; common; banks of the Little Blue River and sedge meadow; BSUH 10585, 10746. [Endangered]

Oenothera biennis L.: Common Evening Primrose; abundant; fields and roadsides; BSUH 10586, 11539.

Orchidaceae (Orchid Family)

Aplectrum hyemale (Muhl.) Torr.: Putty-root; rare, one site with three plants; mesic woods; BSUH 10329.

Liparis liliifolia (L.) Rich.: (+); Large Twayblade or Mauve Sleekwort; infrequent, several sections of young woods with many plants; secondary growth mesic woods; BSUH 11284.

Orchis spectabilis L.: Synonym—*Galearis spectabilis* (L.) Raf.; Showy Orchis; infrequent; scattered in mesic woods; BSUH 11305, 11573.

Spiranthes ovalis Lindl.: (+); Oval Ladies' Tresses; rare, two sites; mesic woods; BSUH 10705. [Watch List]

Orobanchaceae (Broom-rape Family)

Conopholis americana (L.) Wallr.: (+); Squawroot; infrequent; scattered in mesic woods; BSUH 10898, 11117.

Epifagus virginiana (L.) Barton: (+); Beech Drops; rare to infrequent; mesic woods with beech; BSUH 10471, 10760, 11353.

Oxalidaceae (Wood Sorrel Family)

Oxalis dillenii Jacq.: Southern Yellow Wood Sorrel; infrequent; moist fields and riverbanks; BSUH 10653.

Oxalis stricta L.: Common Yellow Wood Sorrel; abundant; fields and woods (widespread); BSUH 11524, 11122.

Oxalis violacea L.: Violet Wood Sorrel; rare; dry upland woods of unit 2; BSUH 10370.

Papaveraceae (Poppy Family)

Chelidonium majus L.: (*,+); Celandine; rare, one site; wooded railroad bed; BSUH 11551.

Papaver rhoeas L.: (c,*,+); Shirley or Corn Poppy; infrequent; fields with prairie plantings; BSUH 10762.

Sanguinaria canadensis L.: Bloodroot; common; mesic woods; BSUH 10907.

Phytolaccaceae (Pokeweed Family)

Phytolacca americana L.: Pokeweed or Pokeberry; common; fields, open woods and roadsides; BSUH 10639.

Plantaginaceae (Plantain Family)

Plantago aristata Michx.: Buckhorn or Bracted Plantain; rare, but abundant at one site; cindery area; BSUH 11528.

Plantago lanceolata L.: (*,+); English Plantain; common; widespread; BSUH 10840.

Plantago major L.: (*,+); Common Plantain; rare, but abundant at one site; gravel parking lot #3 (this plant may now be extirpated as parking lot #3 was covered with asphalt in Fall, 2001); BSUH 11088.

Plantago rugelii Decne.: American Plantain; abundant; widespread; BSUH 10751.

Platanaceae (Plane-tree Family)

Plantanus occidentalis L.: Sycamore; common; floodplain woods, occasionally in mesic woods; BSUH 10588.

Poaceae (Grass Family)

Agrostis gigantea Roth: Synonym—*Agrostis alba* L.; Redtop; abundant; widespread; BSUH 10811, 10828, 11608, 11698.

Andropogon gerardii Vitman: Big Bluestem or Turkey-foot; common; fields with prairie plantings; BSUH 10641.

Andropogon virginicus L.: Broom Sedge; rare, two sites; roadsides and dry field; BSUH 11650, 11685.

Bromus commutatus Schrader: (*); Hairy Chess; infrequent but with large number of plants; disturbed areas; BSUH 10824.

Bromus inermis Leysser: (*); Smooth Brome; abundant; fields; BSUH 10820.

Bromus japonicus Thunb.: (*); Japanese Chess; abundant; fields, disturbed areas and waste places; BSUH 11218, 11388, 11636, 11665.

Bromus pubescens Willd.: (+); Woodland Brome; rare; mesic woods; BSUH 11628.

Bromus racemosa L.: (*,+); Smooth Chess; Brome; common; fields, disturbed areas and waste places; BSUH 11703.

Bromus tectorum L.: (*); Junegrass or Downy Chess; common; fields, disturbed areas and waste places; BSUH 11373, 11638, 11643, 11699, 11702, 11704.

Cinna arundinacea L.: Common Woodreed; abundant; widespread; BSUH 11329.

Dactylis glomerata L.: (*); Orchard Grass; abundant; fields; BSUH 10855, 10856.

Digitaria ischaemum (Schreber) Muhl.: (*,+); Smooth Crabgrass; abundant; roadsides, lawns; fields and waste places; BSUH 10951, 11357.

Echinochloa crusgalli (L.) P. Beauv.: Barnyard Grass; abundant; disturbed areas (often damp); BSUH 11366.

Eleusine indica (L.) Gaertner: (*,+); Yardgrass or Goosegrass; abundant; fields, roadsides and in cracks of cement and asphalt; BSUH 11358, 11520, 11660.

Elymus hystrix L.: Synonym—*Hystrix patula* Moench.; Bottlebrush Grass; abundant; mesic woods; BSUH 11240.

Elymus riparius Wieg.: (+); Streambank Wild Rye; common; floodplain woods and riverbanks; BSUH 10814, 11359.

Elymus villosus Muhl.: Downy Wild Rye; common; mesic woods; BSUH 11588, 11634, 11635.

Elymus virginicus L.: Virginia Wild Rye; abundant; mesic and floodplain woods; BSUH 10817.

Elytrigia repens (L.) Nevski: (*); Synonym—*Agropyron repens* (L.) Beauv.; Quack Grass; common; roadsides, fields and waste places; BSUH 10826, 11221.

Eragrostis cilianensis (All.) Janchen: (*); Stinkgrass; infrequent; disturbed areas and waste places; BSUH 11617.

Eragrostis minor Host.: (+); Synonym—*Eragrostis poaeoides* Roem. & Schult.; Lovegrass; infrequent; in cracks of concrete and asphalt; BSUH 10797, 10799.

Eragrostis pectinacea (Michx.) Nees: Carolina Lovegrass; infrequent; roadsides, fields and waste areas; BSUH 11519.

Festuca elatior L.: (*); Tall or Alta Fescue; abundant; fields; BSUH 10822, 11612.

Festuca subverticillata (Pers.) E. Alexeev.: Synonym—*Festuca obtusa* Biehler; Nodding Fescue; common; ravines and alluvial plains of mesic woods and wildlife plantings in Unit 3; BSUH 10982, 10983, 10984, 10985, 11301.

Glyceria striata (Lam.) A. Hitchc.: Fowl Mannagrass; common; widespread; BSUH 10830, 11318.

Hordeum jubatum L.: Foxtail Barley; common; roadsides; BSUH 11198.

Leersia oryzoides (L.) Swartz: Rice Cutgrass; frequent to common; wet meadows; BSUH 10590.

Leersia virginica Willd.: White Grass; infrequent; ravine bottoms with creeks; BSUH 11334.

Lolium perenne var. *perenne* L.: (*); English Ryegrass; common; roadsides and waste places; BSUH 11487.

Muhlenbergia frondosa (Poiret) Fern.: (+); Muhly; abundant; widespread; BSUH 11337, 11681, 11606, 11678.

Muhlenbergia mexicana (L.) Trin.: Wirestem Muhly; frequent; fen in Unit 1 and fields of Unit 3; BSUH 11343.

Muhlenbergia schreberi J.F. Gmelin: Nimbleweed; infrequent; waste places and railroad bed; BSUH 11338.

Panicum capillare L.: Witch-grass; common; disturbed fields; BSUH 11341.

Panicum dichotomiflorum Michx.: (+); Knee Grass; rare; cindery area; BSUH 11684.

Panicum implicatum Britton (+): Synonym—*Panicum lanuginosum* Elliott var. *implicatum* (Scribn.) Fern; Panic-grass; rare; growing on eroding, moist bank along Little Blue River; BSUH 11342.

Panicum virgatum L.: Prairie Switchgrass; rare; prairie planting in Unit 2; BSUH 11609, 11610, 11630.

Phalaris arundinacea L.: (*,+); Reed Canary Grass; abundant; widespread in wet fields, especially Unit 4; BSUH 0973, 10975.

Phleum pratense L.: (*); Timothy; abundant; fields; BSUH 10809, 11292.

Poa annua L.: (*); Speargrass; infrequent; gravel parking lots and waste places; BSUH 11706.

Poa compressa L.: (*); Canada Bluegrass; common; dry hillsides, roadsides, cindery area and waste places; BSUH 11382, 11384, 11654.

Poa pratensis L.: Kentucky Bluegrass; abundant; fields, roadsides and lawns; BSUH 11137, 11375, 11385.

Poa sylvestris Gray: Forest Bluegrass; infrequent; mesic woods; BSUH 10801, 11349.

Poa trivialis L.: (*,+); Rough Bluegrass; infrequent on the bank of the Big Blue River; BSUH 11632, 11708.

Schizachyrium scoparium (Michx.) Nash: Synonym—*Andropogon scoparius* Michx.; Little Bluestem; infrequent to common; fields with prairie plantings (especially Unit 1); BSUH 11591.

Setaria faberi R. Herrm.: (*,+); Nodding or Giant Foxtail; abundant; disturbed areas and waste places; BSUH 11362.

Setaria glauca (L.) P. Beauv.: (*); Yellow Foxtail Grass; abundant; disturbed areas and waste places; BSUH 11360.

Setaria viridis (L.) P. Beauv.: (*); Green Foxtail Grass; common; disturbed areas, waste places and in crack of concrete; BSUH 11364.

Sorghastrum nutans (L.) Nash: Indian Grass; abundant; fields with prairie plantings; BSUH 11331.

Sorghum halepense (L.) Pers.: (*,+); Johnson Grass; infrequent; fields and roadsides; BSUH 11587.

Sphenopholis intermedia Rybd.: Synonym—*Sphenopholis obtusata* var. *major* (Torr.) Erdman; Slender Wedge Grass; infrequent to common; woodland seeps and moist fields; BSUH 11383, 11700.

Sporobolus vaginiflorus (Torr.) A. Wood: Poverty Grass; rare, one site; cindery area; BSUH 11633.

Tridens flavus (L.) A. Hitch.: (+); Purpletop; abundant; roadsides, fields and in cracks of asphalt; BSUH 10592, 10593, 11326, 11356.

Zea mays L.: (*); Volunteer Corn; infrequent; disturbed fields; BSUH 10722.

Polemoniaceae (Phlox Family)

Phlox divaricata L.: Forest Phlox; abundant; mesic woods; BSUH 10927.

Polemonium reptans L.: Spreading Jacob's Ladder of Greek Valerian; common; mesic woods; BSUH 10882, 10886.

Polygonaceae (Smartweed Family)

Polygonum aviculare L.: (+); Doorweed or Common Knotgrass; abundant; roadsides, lawns, fields and waste places; BSUH 10663.

Polygonum cespitosum Blume: (*,+); Creeping Smartweed; common; mesic woods along paths; BSUH 11064, 11418.

Polygonum hydropiper L.: (*,+); Water Pepper; rare, one large colony; sedge meadow; BSUH 11589.

Polygonum hydropiperoides var. *hydropiperoides* Michx.: (+); False Water Pepper; infrequent; riverbanks; BSUH 11083, 11084, 11651.

Polygonum pensylvanicum L.: Pennsylvania Smartweed; common; fields and disturbed areas; BSUH 10569, 10636, 10655.

Polygonum persicaria L.: (*); Lady's Thumb; abundant; moist fields, disturbed areas and meadows; BSUH 10594.

Polygonum punctatum Elliot: Dotted Smartweed; rare; wet meadows; BSUH 10596, 10672.

Polygonum sagittatum L.: (+); Arrow-leaved Tearthumb; infrequent; wet meadows near Little Blue River; BSUH 10572, 10598.

Polygonum scandens L.: False Climbing Buckwheat; abundant; fields, waste areas, thickets and woodland edges; BSUH 10599, 10651.

Polygonum virginianum L.: Jumpseed or Woodland Knotweed; abundant; mesic woods; BSUH 10601.

Rumex acetosella L.: (*); Red Sorrel; infrequent; upland field of Unit 1; BSUH 11008.

Rumex crispus L.: (*); Curly Dock; abundant; fields, thickets, disturbed areas and roadsides; BSUH 10967.

Rumex obtusifolius L.: (*,+); Bitter Dock; common; wet fields and meadows; BSUH 11238.

Portulacaceae (Purslane Family)

Claytonia virginica L.: Spring Beauty; abundant; mesic woods; BSUH 10879, 10912.

Portulaca oleracea L.: (*,+); Common Purslane; common; disturbed areas; BSUH 11180.

Potamogetonaceae (Pondweed Family)

Potamogeton crispus L.: (*,+); Curly Pondweed; common; Big Blue River; BSUH 11671.

Potamogeton foliosus Raf.: (+); Leafy Pondweed; rare, one site; pond in Unit 4; BSUH 11667, 11673.

Potamogeton nodosus Poiret: (+); Longleaf Pondweed; rare; Big Blue River; BSUH 11687, 11688.

Potamogeton pectinatus L.: (+); Sago Pondweed; common; Big Blue River; BSUH 11664.

Primulaceae (Primrose Family)

Dodecatheon meadia L.: Shooting Star; rare, abundant at one site; dry upland woods; BSUH 11142.

Lysimachia ciliata L.: Fringed Loosestrife; infrequent; wet meadows and woods edge; BSUH 11054.

Lysimachia nummularia L.: (*,+); Moneywort; abundant; moist fields and meadows, wet ground, and floodplain woods; BSUH 10603, 11236.

Lysimachia quadriflora Sims.: Smooth or Narrow-leaved Loosestrife; rare, one site with few plants; sedge meadow; BSUH 11430.

Ranunculaceae (Buttercup Family)

Actaea alba (L.) Miller: (+); Synonym—*Actaea pachypoda* Elliot; Doll's Eyes; infrequent; mesic woods; BSUH 11071.

Anemone canadensis L.: Canadian Anemone; rare, one site; along railroad track near SR 103 in Unit 3; BSUH 11529.

Anemone quinquefolia L. var. *bifolia* Farw.: (+); American Wood Anemone; infrequent; mesic woods; BSUH 10888.

Anemone virginiana L.: Tall Anemone or Thimbleweed; frequent; along railroad track, in successional upland woods, and roadsides; BSUH 10605, 11056.

Anemonella thalictroides (L.) Spach.: Synonym—*Thalictrum thalictroides* (L.) Eames & Boivin; Rue Anemone; frequent; mesic woods; BSUH 10933.

Caltha palustris L.: Marsh Marigold; rare; seeps with skunk cabbage; BSUH 10955.

Clematis virginiana L.: Virgin's Bower; infrequent; edge of floodplain woods next to sedge meadows; BSUH 11045, 10747.

Hepatica acutiloba DC.: Synonym—*Hepatica nobilis* Mill. var. *acuta* (Pursh) Steyermark; Sharp-lobed Hepatica; common; creek banks and ravine slopes in mesic woods; BSUH 10913.

Isopyrum biternatum (Raf.) T. & G.: (+); Synonym—*Enemion biternatum* Raf.; False Rue Anemone or Isopyrum; abundant; mesic and floodplain woods; BSUH 10906.

Ranunculus abortivus L.: Small-flowered or Kidney-leaved Crowfoot; infrequent to common; slope woods and floodplain woods; BSUH 10954, 11599.

Ranunculus hispidus Michx. var. *caricetorum* (Greene) T. Duncan: Synonym—*Ranunculus septentrionalis* Poir.; Hispid (Swamp) Buttercup; infrequent but common at one site; wet meadow and swale; BSUH 10965.

Ranunculus hispidus var. *hispidus* Michx.: Hispid Buttercup; common; creek banks of mesic woods and wet meadows; BSUH 10978.

Ranunculus micranthus Nutt.: (+); Rock or Small-flowered Crowsfoot or Buttercup; infrequent; upland woods; BSUH 10917, 11600.

Ranunculus recurvatus Poiret: Hooked Crowsfoot or Buttercup; infrequent; moist woods and ravines; BSUH 11114, 11156.

Ranunculus sceleratus L.: (z,+), Cursed Crowfoot; rare, one site; standing water in Sweet Flag swale; BSUH 10865.

Thalictrum dasycarpum Fischer & Ave-Lall.: (+); Purple Meadow Rue; rare; banks of Big Blue River and moist field in Unit 1; BSUH 11190, 11473.

Thalictrum dioicum L.: Early Meadow Rue; infrequent; ravine slopes in mesic woods; BSUH 10884.

Thalictrum pubescens Pursh.: (+); Synonym—*Thalictrum polyganum* Muhl.; Tall Meadow Rue; infrequent; meadows; (this collection may possibly be *Thalictrum perelegans* Greene of Deam [1940], but this species is not recognized by Gleason & Cronquist [1991]; BSUH 11265. [Threatened]

Thalictrum revolutum DC.: Waxy or Skunk Meadow Rue; infrequent; bank of Big Blue River and meadows; BSUH 11482.

Rosaceae (Rose Family)

Agrimonia parviflora Aiton: Southern Agrimony; abundant; moist fields; BSUH 10606.

Agrimonia pubescens Wallr.: Downy Agrimony; common; mesic woods; BSUH 10608, 10609, 11085, 11422.

Agrimonia rostellata Wallr.: Woodland Agrimony; infrequent; mesic woods; BSUH 11074.

Chaenomeles speciosa (Sweet) Nakai: (a,*,+);

Common Flowering Quince; rare, one plant, field; BSUH 11511.

Crataegus mollis (T. & G.) Scheele: Downy Hawthorn; abundant; fields, thickets and woods; BSUH 11601.

Crataegus punctata Jacq.: (+); Dotted Hawthorn; abundant; fields, thickets and woods; BSUH 11543.

Filipendula rubra (Hill) B.L. Robinson: Queen of the Prairie; rare, one site with many plants; sedge meadow; BSUH 11048. [Watch List]

Fragaria virginiana Duchesne: Thick-leaved Wild Strawberry; common; widespread but especially in fields; BSUH 10892.

Geum canadense Jacq.: White Avens; abundant; mesic woods; BSUH 10611.

Geum laciniatum Murray: Rough Avens; abundant; fields; BSUH 11232, 11462, 11480.

Geum vernum (Raf.) T. & G.: Spring Avens; infrequent; mesic woods; BSUH 10893, 11135.

Potentilla argentea L.: (*,+); Silvery Five-finger or Cinquefoil; rare, one site with many plants; field; BSUH 11043.

Potentilla norvegica L.: Strawberry Weed; infrequent; fields; BSUH 11531.

Potentilla recta L.: (*); Sulphur Five-fingers; common; fields; BSUH 11257.

Potentilla simplex Michx.: Old Field Five-fingers or Common Cinquefoil; infrequent; fields; BSUH 10098, 10330.

Prunus americana Marshall: Wild Plum; rare, one site; field; BSUH 11479.

Prunus cerasus L.: (b,*,+); Sour Cherry; infrequent; fields; BSUH 11516.

Prunus serotina Ehrh.: Wild Black Cherry; abundant; fields and woods; BSUH 10846, 11123.

Prunus virginiana L.: Choke Cherry; infrequent; low moist areas in mesic woods; BSUH 11420, 11506.

Pyrus coronaria L.: Synonym—*Malus coronaria* (L.) Mill.; Sweet Crab; infrequent; fields and wood's edge; BSUH 11648.

Pyrus malus L.: (b,*,+); Synonym—*Malus malus* (L.) Britton; Apple; infrequent; BSUH 10878, 11604.

Rosa canina L.: (*,+); Dog Rose; infrequent; fields (planted?); BSUH 11248.

Rosa carolina L.: Pasture Rose; common; fields, open areas in woods, and wood's edge; BSUH 11272.

Rosa multiflora Thunb.: (*,+); Multiflora Rose; abundant; widespread in fields and woods (especially young woods); BSUH 10833.

Rosa palustris Marshall: Swamp Rose; rare, one site; riverbank; BSUH 10761, 10770.

Rosa setigera Michx.: Climbing Prairie Rose; common; fields and wood's edge; BSUH 10681, 11196.

Rubus allegheniensis T.C. Porter: (+); Common Blackberry; abundant; fields and wood's edge; BSUH 10969, 10997.

Rubus occidentalis L.: Black Raspberry; abundant; fields, thickets, wood's edge, and roadsides; BSUH 11128.

Rubus pensilvanicus Poiret: Pennsylvania Blackberry; abundant; fields; BSUH 11442.

Spiraea vanhoutei (Briot.) Zabel.: (a,*,+); Bridal Wreath or Spiraea; rare; planted next to building; BSUH 11495.

Rubiaceae (Madder Family)

Diodia teres Walter: (+); Poorjoe or Buttonweed; rare, one site; cindery area of Unit 1; BSUH 11410.

Galium aparine L.: Cleavers; abundant; young woods, floodplain woods, and thickets; BSUH 10959.

Galium asprellum Michx.: Rough Bedstraw; infrequent; mesic woods; BSUH 10612, 11066.

Galium circaezans Michx.: Forest Bedstraw or Wild Licorice; infrequent; mesic woods; BSUH 11276.

Galium concinnum T. & G.: Shining Bedstraw; common to abundant; mesic woods; BSUH 11621.

Galium triflorum Michx.: Sweet-scented Bedstraw; infrequent though locally abundant; floodplain woods and moist fields; BSUH 10757.

Rutaceae (Rue Family)

Ptelea trifoliata var. *trifoliata* L.: Hop Tree; infrequent; along railroad track, stream banks and wood's edge; BSUH 10613, 11226.

Zanthoxylum americanum Miller: Common Prickly Ash; rare, one site in mesic woods with several small individuals; BSUH 11092.

Salicaceae (Willow Family)

Populus deltoides Marshall: Cottonwood; abundant; widespread in moist/wet areas; BSUH 10614, 10854.

Populus grandidentata Michx.: (+); Big-toothed Aspen; rare, one site; dry hilltop forest; BSUH 11536.

Salix amygdaloides Andersson: Peach-leaf Willow; infrequent; wet fields; BSUH 11499.

Salix discolor Michx.: Pussy Willow; rare; seeps; BSUH 11414, 11498.

Salix eriocephala Michx.: (+); Diamond Willow; infrequent; wet fields; BSUH 11408, 11489, 11501.

Salix exigua Nutt.: (+); Sandbar Willow; abundant; wet fields; BSUH 11569.

Salix nigra Marshall: Black Willow; common; wet fields and riverbanks; BSUH 11144, 11467.

Salix pentandra L.: (b,*,+); Bay-leaved Willow; infrequent; wet fields and wood's edge; BSUH 11567.

Salix purpurea L.: (*,+); Basket Willow; rare; wet field; BSUH 11459, 11533, 11571.

Salix × *rubens* Schrank.: (*,+); Hybrid Crack Willow; rare; fens in Unit 4; BSUH 11428.

Saxifragaceae (Saxifrage Family)

Heuchera americana L.: Common Alum Root; infrequent; mesic woods (especially along openings); BSUH 11427.

Mitella diphylla L.: Two-leaved Mitrewort; common; ravine banks and wet areas of mesic woods; BSUH 10925.

Penthorum sedoides L.: Ditch Stonecrop; infrequent; moist open areas; BSUH 10735, 10739.

Scrophulariaceae (Figwort Family)

Chaenorrhinum minus (L.) Lange: (*,+); Lesser Toadflax or Dwarf Snapdragon; rare; waste place; BSUH 11449.

Chelone glabra L.: White Turtlehead; rare; wet meadow; BSUH 10948.

Linaria vulgaris Miller: (*); Butter-and-eggs; rare, one site with many plants; open hillside at shooting range; BSUH 11470.

Mimulus alatus Aiton: (+); Sharpwing Monkey Flower; infrequent; streambanks and alluvial plains in mesic woods; BSUH 10745, 11076.

Mimulus ringens L.: Allegheny Monkey Flower; rare, one site; sandbar in Little Blue River; BSUH 11469.

Pedicularis lanceolata Michx.: Swamp Lousewort; abundant; moist fields in Unit 1; BSUH 10615, 10706.

Penstemon digitalis Nutt.: Tall White Beard Tongue; common in moist upland field of Unit 1; BSUH 11228.

Penstemon laevigatus Aiton: Synonym—*Penstemon calycosus* Small; Eastern or Smooth Beard Tongue; infrequent to common; mesic woods and woodland sedge meadow; BSUH 11264, 11281.

Scrophularia marilandica L.: Eastern Figwort; infrequent; floodplain woods, riverbanks, and successional woods; BSUH 10616, 11081.

Verbascum blattaria L.: (*); Moth Mullein; common; disturbed areas, roadsides and waste places; BSUH 11255, 11263.

Verbascum thapsus L.: (*); Common or Wooly Mullein; common; disturbed areas, roadsides and waste places; BSUH 11034, 11166.

Veronica anagallis-aquatica L.: (+); Water Speedwell; common; Big Blue River; BSUH 11527. [Threatened]

Veronica arvensis L.: (*); Corn Speedwell; common; disturbed areas, roadsides and waste places; BSUH 10844, 10885.

Smilacaceae (Catbrier Family)

Smilax herbacea L. var. *lasioneura* (Small) Rydb.: (+); Carrion Flower (Greenbrier); infrequent; open areas in mesic woods; BSUH 11100.

Smilax hispida Muhl.: Bristly Greenbrier; common to abundant; mesic woods; BSUH 11290.

Solanaceae (Nightshade Family)

Datura stramonium L.: (*); Jimsonweed; infrequent to common; disturbed fields; BSUH 11178.

Physalis longifolia Nutt. var. *subglabrata* (Mack. & Bush) Cronq.: (+); Synonym—*Physalis subglabrata* Mack. & Bush; Longleaf Groundcherry; infrequent; disturbed fields; BSUH 10720, 11508.

Solanum carolinense L.: (+); Horse Nettle; infrequent; disturbed fields; BSUH 11212.

Solanum dulcamara L.: (*,+); Bittersweet; rare; in cattail stand near sedge meadow; BSUH 11433.

Solanum nigrum L.: Black Nightshade; infrequent to common; disturbed fields; BSUH 11181, 11523.

Tiliaceae (Linden Family)

Tilia americana L.: Basswood; American Linden; frequent; mesic woods; BSUH 10618, 11038.

Tilia cordata Miller: (a,*,+); Little-leaved Linden; rare; planted in lawns and at site of old village in Unit 2; BSUH 11436.

Typhaceae (Cattail Family)

Typha angustifolia L.: (+); Narrow-leaved Cattail; rare; sedge meadow; BSUH 10712.

Typha latifolia L.: (+); Common Cattail; infrequent; in dense stands in wet soil or standing water near sedge meadows; BSUH 11429, 11558.

Ulmaceae (Elm Family)

Celtis occidentalis L.: Northern Hackberry; abundant; woods, especially floodplain and successional; BSUH 11021.

Ulmus americana L.: White (American) Elm; abundant; woods, especially floodplain and successional; BSUH 10619, 10915.

Ulmus pumila L.: (b,*,+); Siberian Elm; common; old building sites and old village; BSUH 10620.

Ulmus rubra Muhl.: Slippery or Red Elm; abundant; mesic woods; BSUH 10732.

Urticaceae (Nettle Family)

Boehmeria cylindrica (L.) Swartz: False Nettle; rare, two sites; moist field in Unit 4 and floodplain woods in Unit 1; BSUH 10562, 11477.

Laportea canadensis (L.) Wedd.: (+); Wood Nettle; abundant; floodplain woods and alluvial plains in mesic woods; BSUH 10621, 10622.

Pilea pumila (L.) A. Gray: Clearweed; abundant; floodplain woods and wet shaded places; BSUH 10624, 10625.

Urtica dioica L. var. *procera* (Muhl.) Wedd.: Synonym—*Urtica procera* Willd.: Tall Nettle or Tall Stinging Nettle; abundant; moist fields, meadows and floodplain woods; BSUH 10627, 10628, 10629, 11016, 11195.

Valerianaceae (Valerian Family)

Valeriana pauciflora Michx.: (+); Long-tube Valerian; infrequent; alluvial plains; BSUH 11153.

Valerianella umbilicata (Sulliv.) A. Wood: (+); Corn Salad; abundant; moist fields and meadows; BSUH 11132.

Verbenaceae (Vervain Family)

Phryma leptostachya L.: Lopseed; frequent; mesic woods; BSUH 10631, 10773.

Verbena bracteata Lagasca & Rodriguez: (+); Prostrate or Creeping Vervain; frequent; roadsides and crack in asphalt; BSUH 10698.

Verbena hastata L.: Common (Blue or Violet) Vervain; frequent; moist fields and meadows; BSUH 10632.

Verbena urticifolia L.: White Vervain; frequent; moist fields and meadows; BSUH 11087.

Violaceae (Violet Family)

Viola cucullata Aiton: (+); Blue Marsh Violet; infrequent; sedge meadow; BSUH 11010.

Viola priceana Willd.: (b,*,+); Synonym—*Viola sororia* Willd.; Confederate Violet; infrequent; upland mesic woods; (see Gleason & Cronquist (1991) for a description of this species); BSUH 10860.

Viola pubescens Aiton: Forest Yellow Violet; common; mesic woods; BSUH 10920.

Viola sororia Willd.: Dooryard Violet or Common Blue Violet; abundant; mesic woods, moist fields and lawns; BSUH 10874, 11130.

Viola striata Aiton: Creamy Violet; common; mesic and floodplain woods; BSUH 10924.

Vitaceae (Grape Family)

Parthenocissus quinquefolia (L.) Planchon: Virginia Creeper; abundant; widespread especially in woods; BSUH 10852, 10938, 11191.

Vitis riparia Michx.: River or Frost Grape; common; mesic and floodplain woods; BSUH 10634.

Vitis vulpina L.: Frost Grape; common; mesic and floodplain woods; BSUH 11252.

Zannichelliaceae (Horned Pondweed Family)

Zannichellia palustris L.: (+); Horned Pondweed; infrequent; Big Blue River; BSUH 11663. [Endangered]

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REPORTS OF RARELY COLLECTED OR PREVIOUSLY UNREPORTED INDIANA COLEOPTERA (INSECTA): CERAMBYCIDAE, CEROPHYTIDAE, HYDRAENIDAE, HYDROPHILIDAE, NITIDULIDAE, SCARABAEIDAE, STAPHYLINIDAE, TROGOSSITIDAE

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ABSTRACT. Eleven species of Indiana Coleoptera are newly reported or reported as rarely-collected species in the State. The rare species *Cerophytum pulsator* (Cerophytidae) is noted from southern Indiana. *Temnoschiela virescens* (Trogossitidae) was first detected in 1989 but has been found in abundance in 2000. *Carpophilus humeralis* (Nitidulidae) is newly reported and was taken most frequently in bee hives. *Hesperus stehri* (Staphylinidae)has been taken in four collections representing the first Indiana records. *Hesperus apicialis* was thought to be rare but has been encountered throughout southern Indiana. *Quedius terminatus* is reported from southern Indiana. The European adventive *Onthophagus taurus* (Scarabaeidae) is reported from far southern Indiana. Several common species that have been overlooked in Indiana are reported for the first time including *Dectes texanus* (Cerambycidae), *Gymnochthebius nitidus* (Hydraenidae), *Helophorus linearis* (Hydrophilidae), and *Stictocranius puncticeps* (Staphylinidae). An additional new county record is provided for the rarely collected *Hydraena quadricurvipes* (Hydraenidae), known only from the mouths of caves.

Keywords: Insecta, Coleoptera, Indiana

The Coleoptera of Indiana are generally well known and documented based on historical collections of Indiana beetles by collectors and published treatises by W.S. Blatchley (1910), Downie & Arnett (1996), and others. Collections from infrequently-sampled sites in Indiana, and collections of non-target beetles that were taken as a result of exotic scolytid trapping efforts by the United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA APHIS PPQ) and the Indiana Department of Natural Resources were recently studied. In part, these collections form the basis of this report. Lindgren funnel traps baited with pheromones for exotic bark beetles (Scolytidae) were placed in close proximity to international port sites on Lake Michigan in Indiana (Burns Harbor) and ports along the Ohio River near coniferous forests to detect possible introductions of exotic bark beetles of state and national concern, including *Ips typographus* (L.), *Orthotomicus erosus* (Wollaston), and *Hylurgus ligniperda* (L.). In addition, Lindgren funnel traps baited with the host volatile, alpha pinene, were placed in counties adjacent to counties regulated for the introduced and federally regulated species pine shoot beetle [*Tomicus piniperda* (L.) (Coleoptera: Scolytidae)] to monitor expansion of established populations of this species throughout Indiana (visit the following National Agricultural Pest Information Service (NAPIS) website for details of pine shoot beetle advancement in North America: http://www.ceris.purdue.edu/napis/states/wv/psb/wvpsb.html).

Material reported herein includes collections made through several different techniques including sweeping, pitfall traps, and baited Lindgren funnel traps. Material was identified by use of Downie & Arnett (1996), Arnett & Thomas (2001), Arnett (1960) and current taxonomic revisions. Comparative determinations were made using Blatchley (1910), but final determinations were reliant on more recent literature.

Vouchers for all reported species herein are deposited at Purdue University, Purdue Entomological Research Collection (PERC), West

Lafayette, Indiana. Vouchers were compared with identified material housed at Purdue University. Mike Brattain, West Lafayette, confirmed identifications. Data reported establishes a county voucher; not all specimens taken in any given county are reported.

SPECIES REPORTS

Cerambycidae

***Dectes texanus* LeConte.**—This distinctive species is widespread in North America and in the northeastern states (Downie & Arnett 1996). It is known from both Ohio and Illinois. Its discovery in Indiana is not surprising.

New state report: INDIANA: *Hamilton County*, 6 August 1998, R.D. Waltz and G.R. Jansen, on giant ragweed.

Cerophytidae

***Cerophytum pulsator* (Haldeman).**—Blatchley (1910) did not collect this species in Indiana although he reported its collection by Drury in Ohio and predicted its eventual collection in Indiana. Virtually nothing is known about the biology of this elusive species (Arnett 1960; Arnett, Downie & Jacques 1980). In this study, mixtures of males and females were taken in Lindgren funnel traps using triple lure. Specimens have not been taken in the alpha pinene traps. The species is known to be associated with dead wood, and all new Indiana collections were taken in declining coniferous, and mixed conifer/deciduous woodlands. It was previously reported (Downie 1970) in Indiana on the basis of one male from Montgomery County, 23 May 1970 (PERC).

New county reports: INDIANA: *Clark County Pinus* sp. 17 April 1998, T. Vawryk, (1♂,1♀); *Harrison County Pinus resinosa*, *P. strobus*, April 1999, T. Vawryk, (17 individuals); 5 May 1998, T. Vawryk, (7 individuals); *Jefferson County*, Madison, 21 May 1999, T. Vawryk, (5 individuals); 17 April 1998, T. Vawryk (5 individuals).

Hydraenidae

***Gymnochthebius nitidus* (LeConte).**—This collection containing several individuals was taken in one trap approximately one meter from the stream's edge in grass. The species is widespread in North America (Perkins 1980). Its report from Indiana is not surprising.

New state report: INDIANA: *Wayne County*, Milton, J.W. Hart farm, 21 March 1998 (98-18b) in pitfall trap, mixed glacial till substrate in wooded riparian site.

***Hydraena quadricurvipes* Perkins.**—(Bow-Legged Minute Moss Beetle.) This striking species is known to occur in the mouth of caves in the few instances it has been reported (Perkins 1980). Earlier Indiana records of this species were from Monroe County near Needmore. What little is known about the species' biology is reported by Perkins (1980).

New county report: INDIANA: *Crawford County*, Wyandotte Cave State Recreation area, Jug Hole Pit, 1 June 1998, J. Lewis & V. Lewis.

Hydrophilidae

***Helophorus (Rhopalelophorus) linearis* LeConte.**—This common species was reported from both Ohio and Illinois (Smetana 1988; Downie & Arnett 1996) but had not been previously reported from Indiana. This report is based on a specimen collected from a small, grassy hummock isolated from the shore of a pond. The occurrence of this common species in Indiana is not surprising.

New state report: INDIANA: *Perry County*, Buzzard Roost, pond edge, 3 April 1998, R.D. Waltz, D.R. Waltz, and S. Olsen.

Nitidulidae

***Carpophilus humeralis* (Fabricius).**—This species is known from the southeastern United States and from California where it is known to be a pest of grains. It is a rather distinctive species and would not have been easily overlooked in previous surveys. It is possible that it has been introduced through beekeeping, and has become recently established in northern Indiana. Specimens were almost exclusively found in bee hives.

New state report: INDIANA: *Jasper County*, Remington, *ex* bee hive, 14 June 2000; *Koskiusko County*, Scott Township, Etna Green, *ex* bee hive, 22 May 2000; *Marshall County*, Plymouth, *ex* bee hive, 30 June 2000; *Montgomery County*, Crawfordsville, *ex* bee hive, 17 June 2000; Montgomery County, Ladoga, *ex* bee hive, 1 June 2000; *Newton County*, Morocco, *ex* bee hive, 25 May 2000; *Porter County*, port of entry, Burns Harbor, Trap 13, 24 May 1999, C. Gallowitch; *Tippecanoe*

County, Lafayette, *ex* bee hive, 18 August 2000; West Lafayette, *ex* bee hive, 27 May 2000; West Point, *ex* bee hive, 20 May 2000; *White County*, Brookston, *ex* bee hive, 27 May 2000; *White County*, Idaville, *ex* bee hive, 26 May 2000.

Scarabaeidae

***Onthophagus taurus* Schreber.**—This European species was first reported in Indiana by Smith (1997) in Tippecanoe County, approximately 100 km south of Chicago. The first North American record of this species was taken in the State of Florida. It has apparently moved steadily northward. Herein I am reporting an additional collection of this species from near the Ohio River indicating that the species is probably, and predictably, widespread in Indiana.

New county report: INDIANA: *Vanderburgh County*, Evansville, port of entry, April 1998, T. Vawryk.

Staphylinidae

***Hesperus apicialis* (Say).**—This distinctive species was reported as rare by Blatchley (1910) and was found to be represented previously by only two specimens in the Purdue Entomological Research Collection, also supporting the perception that it is uncommonly collected. Numerous collections of this species have been made in baited Lindgren funnel traps, and in fact the species is abundant and widespread. Collection data indicates this species is active from early March through September.

New county reports: (All taken in Lindgren funnel traps baited with triple lure or alpha pinene.) INDIANA: *Brown County*, April 2000, K. Kerras; *Clark County*, 14 May 1999, T. Vawryk; *Fayette County*, May 1999, M. Chandler; *Harrison County*, 9 June 1999, T. Vawryk; *Jefferson County*, 21 April 1999, T. Vawryk; *Martin County*, May 1998, T. Vawryk; *Morgan County*, May 2000, K. Kerras; *Perry County*, 11 June 2001, T. Vawryk; *Pike County*, 5 May 2001, D. Fisher; *Porter County*, 13 April 1999, C. Gallowitch; *Posey County*, 19 April 2001, D. Fisher; 6 May 1999, T. Vawryk; *Putnam County*, June 2000, T. Vawryk; *Scott County*, 8 March 2000, T. Vawryk; *Spencer County*, 11 July 2001, T. Vawryk; *Union County*, May 2000, K. Dickerson; *Vanderburgh County*, Evansville, port of entry, July 1999, T. Vawryk; *Vigo County*, May 2000, K. Kerras.

***Hesperus stehri* Moore.**—This species, the largest of North American *Hesperus* species, is not well represented in collections. Smetana (1995) reported only 11 specimens studied, from Arkansas, Georgia, Kansas, Ohio, Oklahoma, Tennessee, and Texas. The species has been taken in Lindgren funnel traps using triple lure bait and alpha pinene bait from pine areas in southern Indiana.

New state report: INDIANA: *Clark County*, 29 April 1998, in *Pinus*, (pheromone trap), T. Vawryk; *Harrison County*, April 1998, (pheromone trap), T. Vawryk; *Morgan County*, (alpha pinene trap), May 2000, K. Kerras; *Vanderburgh County*, Evansville, port of entry, (pheromone trap), July 1999, T. Vawryk.

***Quedius* (*Microsaurus*) *terminatus* Melsheimer.**—This rarely reported species (Smetana 1971) was taken in this study with collections of *Hesperus apicialis*, *H. baltimorensis*, and *H. stehri*. The species shares with *H. apicialis* and *H. stehri* the reddish terminal segments of the abdomen. Previously reported in Indiana from Turkey Run State Park in Parke County, Marshall (Smetana 1971).

New county reports: INDIANA: *Clark County*, 17 April 1998, T. Vawryk; *Harrison County*, April 1999, T. Vawryk; *Jefferson County*, April 1998, T. Vawryk. All collections taken in Lindgren funnel trap, baited with triple lure.

***Stictocranius puncticeps* LeConte.**—Widespread in the eastern United States (Puthz 1974), this species has been overlooked in previous Indiana collections. It occurs with limited frequency in Tullgren extraction and leaf litter samples. It is been known for several years in Indiana but not formally reported or vouchered.

New state reports: INDIANA: *Fayette County*, Manlove Woods, Tullgren extraction, sample drawn from old, fallen tree, 1 May 2000, J.W. Hart; *Tippecanoe County*, 9 October 1974, R.D. Waltz.

Trogossitidae

***Temnoscheila virescens* (Fabricius).**—This distinctive, bright metallic green species is widespread in more southern regions of the nation (e.g., Leschen 2002) and has not been reported previously from Indiana (Downie & Arnett 1996), nor was it represented in the

Purdue University insect collection (the Indiana state insect collection). It has been taken within the past two years from triple lure traps in Indiana and is a species known to be attracted to bark beetle pheromones (Billings & Cameron 1984). Based on a virtually identical survey conducted in 1989, one individual of this species was discovered in Crawford County, taken in a Lindgren funnel trap baited with alpha pinene, but was previously unidentified among non-target species taken. A similar survey conducted in 1990 did not result in collections of *T. virescens* in any county. In the years 2000 and 2001, this species was found in significant numbers in counties adjoining the Ohio River. It appears to be recently adventive in Indiana. Available data indicate this species is active in Indiana from early March through September.

New state reports: (All specimens in Lindgren funnel traps with triple lure except 1989 report.) INDIANA: *Clark County*, 29 April 1998, T. Vawryk; *Crawford County*, Lindgren funnel trap, alpha pinene, 23 May to 9 June 1989; *Dubois County*, 19 April 2000, D. Fisher; *Harrison County*, April 1998, T. Vawryk; *Jackson County*, red pine, March 2000, T. Vawryk; *Jefferson County*, Madison, 22 June 1999, T. Vawryk; *Perry County*, Hoosier National Forest, 11 June 2000, T. Vawryk; *Pike County*, 5 April 2001, D. Fisher; *Scott County*, ardy Lake State Recreation Area, 21 May 2001, T. Vawryk; *Spencer County*, Lincoln State Park, 11 June 2000, T. Vawryk; *Vanderburgh County*, port of entry, July 1999, T. Vawryk.

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REVISED CHECKLIST OF THE VERTEBRATES OF INDIANA

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ABSTRACT. The vertebrate fauna of Indiana recorded since the time of European settlement numbers 208 fish, 38 amphibian, 54 reptilian, 401 avian, and 68 mammalian species. Currently, 19 fish, 9 amphibian, 16 reptilian, 44 avian, and 13 mammalian species within the political boundaries of Indiana require protection due to man's impact. Within the last 200 years, 26 native vertebrate species in Indiana have become extinct or extirpated. These include 6 fish, 1 reptilian, 8 avian, and 11 mammalian species. The present vertebrate fauna of Indiana has 203 fish, 38 amphibian, 53 reptilian, 393 avian, and 57 mammalian species.

Keywords: Indiana, fishes, reptiles, amphibians, mammals, birds

The current listing is intended to provide a record of the extant and extirpated vertebrates of Indiana over the last two centuries. The list was first published by Simon et al. (1993) and is updated here. It includes new information and taxonomic changes. This is the first step in the efforts of the Biological Survey Committee of the Indiana Academy of Science to compile a listing of all the known species of biota in Indiana. The taxonomic and nomenclatural sources used for the various taxa include: *Fish:* American Fisheries Society (1991), Burr & Warren (1986), Mayden (1989), and Etnier & Starnes (1993); *Amphibians and reptiles:* Minton (1972, 2001), Collins (1990), and Conant & Collins (1991); *Birds:* American Ornithologists' Union (1998); *Mammals:* Wilson & Reeder (1993) and Mumford & Whitaker (1982).

The following codes were established to facilitate documentation of the vertebrates of the state (Tables 1, 2). The general range in Indiana is indicated as: statewide (I), north (N), south (S), west (W), east (E), central (C), and various combinations of these regions. Relative abundance refers to the general population levels of the species within the state. Depending on local and seasonal conditions, the population levels will vary. Relative abundance is broken down into four categories: A = abundant, C = common, O = occasional, and R = rare. Abundance categories vary based on size of the animal. Extirpated species (Ex) are listed along with the estimated date of disappearance. In some cases, this date refers to the last time a voucher record of the species was collected (Whitaker & Gammon 1988). The status of the species refers to the conservation designations of the U.S. Fish and Wildlife Services Office of Endangered Species, Endangered and Threatened Wildlife and Plants (USOFR 1996) and of the Indiana Department of Natural Resources summarized in *Rare Animals of Indiana* (Indiana Department of Natural Resources 1999). Federally endangered species are denoted as FE, threatened as FT, and candidates for federal listing as FC. State endangered species will be represented by three codes: state endangered (SE), state threatened (ST), and special concern in need of further study (SC). An additional designation, exotic (X), is included for accidentally or deliberately released species. One additional code is included for birds (Table 2) to indicate main seasonal occurrence: S = summer resident, W = winter resident, R = year-round resident, M = migrant, A = accidental, H = hypothetical, and * = breeder and [*] = former breeders. The listing of birds has been greatly improved due to the establishment and work of the Indiana Bird Records Committee of the Indiana Audubon Society.

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[1] *Deceased.*

DISCUSSION

The vertebrate fauna of Indiana recorded from the time of European settlement numbers 203 fish, 38 amphibian, 54 reptilian, 401 avian, and 68 mammalian species. Species first described as new from Indiana include 34 fish, 3 amphibians, 6 reptiles, and 2 mammals. Within the last 200 years, 26 native vertebrate species in Indiana have become extinct or extirpated. Of those lost, 6 species were fish; 1 was a reptile; 8 were birds; and 11 were mammals. Another 18 bird species (13 not including extirpated species) no longer nest in the state. Through accidental or deliberate release, 21 species of fish and 9 additional bird species have become established, although one of these bird species has been recently lost. Currently, 19 fish, 9 amphibian, 16 reptilian, 44 avian, and 13 mammalian species within the political boundaries of Indiana require protection due to man's impact. An additional 6 amphibian, 3 reptilian, 30 avian, and 2 mammalian species are considered hypothetical in occurrence in the state because specimens have not been collected. The present faunal list for Indiana includes 203 fish, 38 amphibian, 53 reptile, 393 bird, and 57 mammal species.

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Table 1.—Checklist of the fish, amphibians, reptiles, and mammals of Indiana. Range is indicated as statewide (I), north (N), south (S), west (W), east (E), central (C), and various combinations. General abundance is listed roughly as abundant (A), common (C), occasional (O), and rare (R). Extirpated species (Ex) are given with approximate date of extirpation. Status is listed as federally endangered (FE), federally threatened (FT), and candidates for federal listing (FC). State designations are endangered (SE), threatened (ST), and special concern (SC). Exotic or introduced species are indicated by "X."

	Range	Relative abundance	Status
CLASS OSTEICHTHYES			
Order Petromyzontiformes (lampreys)			
Family Petromyzontidae (lamprey)			
Ichthyomyzon bdellium (Jordan), Ohio lamprey	W, S	R	
I. castaneus Girard, chestnut lamprey	SW	O	
I. fossor Reighard & Cummins, northern brook lamprey	NE	R	
I. unicuspis Hubbs & Trautman, silver lamprey	W, S	O	
Lampetra aepyptera (Abbott), least brook lamprey	SW	R	
L. appendix (DeKay), American brook lamprey	NW	O	
Petromyzon marinus Linnaeus, sea lamprey	NW	O	X
Order Acipenseriformes (paddlefish, sturgeons)			
Family Acipenseridae (sturgeon)			
Acipenser fulvescens Rafinesque, lake sturgeon	W, S	R	SE
Scaphirhynchus platorynchus (Rafinesque), shovelnose sturgeon	W, SE	O	
Family Polyodontidae (paddlefish)			
Polyodon spathula (Walbaum), paddlefish	W, SE	O	
Order Lepisosteiformes (gars)			
Family Lepisosteidae (gars)			
Lepisosteus oculatus Winchell, spotted gar	NE, SW	O	
L. osseus Linnaeus, longnose gar	I	C	
L. platostomus Rafinesque, shortnose gar	W, S	O	
Order Amiiformes (bowfin)			
Family Amiidae (bowfin)			
Amia calva Linnaeus, bowfin	N, S	O	
Order Osteoglossiformes (mooneye)			
Family Hiodontidae (mooneye)			
Hiodon alosoides (Rafinesque), goldeye	S	O	
H. tergisus LeSueur, mooneye	W, S	O	
Order Anguilliformes (eels)			
Family Anguillidae (eel)			
Anguilla rostrata (LeSueur), American eel	W, S	R	

Table 1.—Continued.

	Range	Relative abundance	Status
Order Clupeiformes (herring, shad)			
Family Clupeidae (herring)			
Alosa chrysochloris (Rafinesque), skipjack herring	W, S	C	
A. pseudoharengus (Wilson), alewife	NW	A	X
Dorosoma cepedianum (LeSueur), gizzard shad	I	A	
D. petenense (Günther), threadfin shad	S	C	X
Order Cypriniformes (carps and minnows)			
Family Cyprinidae (carps and minnows)			
Campostoma anomalum (Rafinesque), stoneroller	I	A	
C. oligolepis Hubbs & Greene, largescale stoneroller	N	A	
Carassius auratus (Linnaeus), goldfish	I	C	X
Clinostomus elongatus (Kirtland), redside dace	E	R	ST
Couesius plumbeus (Agassiz), lake chub	NW	R	
Ctenopharyngodon idella (Valenciennes), grass carp	NW, C	O	X
Cyprinella lutrensis (Baird & Girard), red shiner	NW	O	X
C. spiloptera (Cope), spotfin shiner	I	A	
C. whipplei Girard, steelcolor shiner	C, S	C	
Cyprinus carpio Linnaeus, carp	I	A	X
Ericymba buccata Cope, silverjaw minnow	I	C	
Erimystax dissimilis (Kirtland), streamline chub	NW	R	
E. x-punctatus (Hubbs & Crowe), gravel chub	W	R	
Hybognathus hayi Jordan, cypress minnow	SW	R	
H. nuchalis Agassiz, Mississippi silvery minnow	SC, SW	C	
Hybopsis amblops (Rafinesque), bigeye chub	NW	C	
H. amnis (Hubbs & Greene), pallid shiner	W	R	SE
Hypophthalmichthys molitrix (Valenciennes), silver carp	SE, SW	R	X
H. nobilis (Richardson), bighead carp	SW	O	X
Luxilus chrysocephalus Rafinesque, striped shiner	I	A	
L. cornutus (Mitchill), common shiner	N	O	
Lythrurus fasciolaris (Gilbert), scarlet shiner	SE	C	
L. fumeus (Evermann), ribbon shiner	SW	R	
L. umbratilis (Girard), redfin shiner	W, C	C	
Macrhybopsis hyostoma (Gilbert), shoal chub	W, S	O	
M. storeriana (Kirtland), silver chub	W	C	
Nocomis biguttatus (Kirtland), hornyhead chub	N	C	
N. micropogon (Cope), river chub	NE, C	C	

Table 1.—Continued.

	Range	Relative abundance	Status
Notemigonus crysoleucas (Mitchill), golden shiner	I	C	
Notropis atherinoides Rafinesque, emerald shiner	I	A	
N. blennius (Girard), river shiner	W, S	C	
N. boops Gilbert, bigeye shiner	C	C	
N. buchanani Meek, ghost shiner	NW, S	O	
N. chalybaeus (Cope), ironcolor shiner	NW	O	
N. dorsalis (Agassiz), bigmouth shiner	NW	R	SE
N. heterodon (Cope), blackchin shiner	N	R	
N. heterolepis Eigenmann & Eigenmann, blacknose shiner	N	R	
N. hudsonius (Clinton), spottail shiner	NW	A	
N. photogenis (Cope), silver shiner	C, SE	O	
N. rubellus (Agassiz), rosyface shiner	N, C	C	
N. shumardi (Girard), silverband shiner	SW	C	
N. stramineus (Girard), sand shiner	I	A	
N. texanus (Girard), weed shiner	NW	R	
N. volucellus (Cope), mimic shiner	E, C, S	O	
N. wickliffi Trautman, channel shiner	S	C	
Opsopoeodus emiliae Hay, pugnose minnow	N, SW	R	
Phenacobius mirabilis (Girard), suckermouth minnow	C, S	C	
Phoxinus erythrogaster (Rafinesque), southern redbelly dace	NW, C	O	
Pimephales notatus (Rafinesque), bluntnose minnow	I	A	
P. promelas Rafinesque, fathead minnow	N, SE	C	
P. vigilax (Baird & Girard), bullhead minnow	W, S	O	
Rhinichthys atratulus (Hermann), blacknose dace	NW, C, SE	C	
R. cataractae (Valenciennes), longnose dace	N	O	
Semotilus atromaculatus (Mitchill), creek chub	I	A	
Scardinius erythrophthalmus (Linnaeus), rudd	NW	R	X
Family Catostomidae (suckers and buffalo)			
Carpiodes carpio (Rafinesque), river carpsucker	W, S	C	
C. cyprinus (LeSueur), quillback	I	C	
C. velifer (Rafinesque), highfin carpsucker	W, S	O	
Catostomus catostomus (Forster), longnose sucker	NW	R	
C. commersoni (Lacepède), white sucker	I	A	
Cycleptus elongatus (LeSueur), blue sucker	C, S	O	FC
Erimyzon oblongus (Mitchill), creek chubsucker	NW, C, SW	O	
E. sucetta (Lacepède), lake chubsucker	N	O	
Hypentelium nigricans (LeSueur), northern hogsucker	N, C	C	

Table 1.—Continued.

	Range	Relative abundance	Status
Ictiobus bubalus (Rafinesque), smallmouth buffalo	W, S	C	
I. cyprinellus (Valenciennes), bigmouth buffalo	W, S	O	
I. niger (Rafinesque), black buffalo	NW, S	R	
Minytrema melanops (Rafinesque), spotted sucker	NE, C	C	
Moxostoma anisurum (Rafinesque), silver redhorse	N, C	C	
M. carinatum (Cope), river redhorse	C	O	
M. duquesnei (LeSueur), black redhorse	C	C	
M. erythrurum (Rafinesque), golden redhorse	I	A	
M. macrolepidotum (LeSueur), shorthead redhorse	I	A	
M. valenciennesi Jordan, greater redhorse	N	R	SE
Order Siluriformes (bullhead and catfish)			
Family Ictaluridae (bullhead and catfish)			
Ameiurus catus (Linnaeus), white catfish	S	O	X
A. melas (Rafinesque), black bullhead	I	A	
A. natalis (LeSueur), yellow bullhead	I	A	
A. nebulosus (LeSueur), brown bullhead	S	C	
Ictalurus furcatus (LeSueur), blue catfish	S	O	
I. punctatus (Rafinesque), channel catfish	I	C	
Noturus eleutherus Jordan, mountain madtom	W, C	O	
N. flavus Rafinesque, stonecat	I	C	
N. gyrinus (Mitchill), tadpole madtom	I	C	
N. miurus Jordan, brindled madtom	C	O	
N. nocturnus Jordan & Gilbert, freckled madtom	W	O	
N. stigmosus Taylor, northern madtom	WC	R	
Pylodictis olivaris (Rafinesque), flathead catfish	I	C	
Order Salmoniformes (trout, salmon, whitefish)			
Family Esocidae (pikes)			
Esox americanus Gmelin, grass pickerel		C	
E. lucius Linnaeus, northern pike	N	O	
E. masquinongy Mitchill, muskellunge	S	R[a]	
Family Umbridae (mudminnows)			
Umbra limi (Kirtland), central mudminnow	N	A	

Table 1.—Continued.

	Range	Relative abundance	Status
Family Osmeridae (smelt)			
Osmerus mordax (Mitchill), rainbow smelt	NW	C	X
Family Salmonidae (salmon and whitefish)			
Coregonus artedi LeSueur, cisco or lake herring	NW	R	SC
C. clupeaformis (Mitchill), lake whitefish	NW	C	SE
C. hoyi (Milner), bloater	NW	R	
C. kiyi (Koelz), kiyi	NW	R	
C. zenithicus (Jordan & Evermann), shortjaw cisco	NW	R	
Oncorhynchus kisutch (Walbaum), coho salmon	NW	C	X
O. mykiss (Walbaum), rainbow trout	N	C	X
O. tshawytscha (Walbaum), chinook salmon	NW	C	X
Salmo salar Linnaeus, Atlantic salmon	NW	O	X
S. trutta Linnaeus, brown trout	N	C	X
Salvelinus fontinalis (Mitchill), brook trout	NW	R	
S. namaycush (Walbaum), lake trout	NW	O	
Order Aphredoderiformes (cavefish, pirate perch, trout-perch)			
Family Aphredoderidae (pirate perch)			
Aphredoderus sayanus (Gilliams), pirate perch	N, SW	C	
Family Amblyopsidae (cavefish)			
Amblyopsis spelaea (DeKay), northern cavefish	S	R	SE, FC
Typhilchthys subterraneus Girard, southern cavefish	S	R	SE
Order Percopsiformes			
Family Percopsidae (trout-perch)			
Percopsis omiscomaycus (Walbaum), trout-perch	NW, S	R	
Order Gadiformes (cod)			
Family Lotidae (freshwater cod)			
Lota lota (Linnaeus), burbot	NW, WE	O	
Order Cyprinodontiformes (topminnows, silversides)			
Family Fundulidae (topminnows)			
Fundulus catenatus (Storer), northern studfish	C	C	
F. diaphanus (LeSueur), banded killifish	N	C	
F. dispar (Agassiz), northern starhead topminnow	NW	C	
F. notatus (Rafinesque), blackstripe topminnow	I	A	
F. olivaceus (Storer), blackspotted topminnow	W, NE	R	
Family Poeciliidae (live-bearing fishes)			
Gambusia affinis (Baird & Girard), mosquitofish	W	O	

Table 1.—Continued.

	Range	Relative abundance	Status
Order Atheriniformes			
Family Atherinidae (silversides)			
Labidesthes sicculus (Cope), brook silverside	I	C	
Menidia beryllina (Cope), inland silverside	S	R	X
Order Mugiliformes			
Family Mugilidae			
Mugil cephalus Linnaeus, striped mullet	S	R	X
Order Gasterosteiformes (sticklebacks)			
Family Gasterosteidae (sticklebacks)			
Culaea inconstans (Kirtland), brook stickleback	N, SE	C	
Gasterosteus aculeatus Linnaeus, threespine stickleback	NW	O	X
Pungitius pungitius (Linnaeus), ninespine stickleback	NW	O	
Order Scorpaeniformes			
Family Cottidae (sculpins)			
Cottus bairdi (Girard, mottled sculpin	I	C	
C. carolinae (Gill), banded sculpin	SC	O	
C. cognatus Richardson, slimy sculpin	NW	R	
Myoxocephalus thompsoni (Girard), deepwater sculpin	NW	R	
Order Perciformes (basses, sunfish, perch, darters, gobies)			
Family Moronidae (temperate basses)			
Morone americana (Gmelin), white perch	NW	R	X
M. chrysops (Rafinesque), white bass	W	C	
M. mississippiensis Jordan & Eigenmann, yellow bass	W, S	O	
M. saxatilis (Walbaum), striped bass	S	O	X
Family Elassomatidae (pygmy sunfish)			
Elassoma zonatum Jordan, banded pygmy sunfish	SW	R	
Family Centrarchidae (black bass and sunfish)			
Ambloplites rupestris (Rafinesque), rock bass	I	C	
Centrarchus macropterus (Lacepède) flier	SW	O	
Lepomis cyanellus Rafinesque, green sunfish	I	A	
L. gibbosus (Linnaeus), pumpkinseed	I	C	
L. gulosus (Cuvier), warmouth	N	C	
L. humilis (Girard), orangespotted sunfish	N	O	
L. macrochirus Rafinesque, bluegill	I	A	
L. megalotis (Rafinesque), longear sunfish	I	A	

Table 1.—Continued.

	Range	Relative abundance	Status
L. microlophus (Günther), redear sunfish	N, S	C	
L. miniatus Jordan, redspotted sunfish	SW	R	
L. symmetricus Forbes, bantam sunfish	W	R	ST
Micropterus dolomieu Lacepède, smallmouth bass	I	A	
M. punctulatus (Rafinesque), spotted bass	S	A	
M. salmoides (Lacepède), largemouth bass	I	A	
Pomoxis annularis Rafinesque, white crappie	I	C	
P. nigromaculatus (LeSueur), black crappie	I	C	
Family Percidae (perch and darters)			
Ammocrypta clara Jordan & Meek, western sand darter	NW, S	O	
A. pellucida (Agassiz), eastern sand darter	C, SW	O	SC, FC
Etheostoma asprigene (Forbes), mud darter	S	C	
E. blennioides Rafinesque, greenside darter	C, E	C	
E. caeruleum Storer, rainbow darter	N, C	C	
E. camurum (Cope), bluebreast darter	C	R	
E. chlorosoma (Hay), bluntnose darter	W	R	
E. exile (Girard), Iowa darter	N	O	
E. flabellare Rafinesque, fantail darter	E, C	C	
E. gracile (Girard), slough darter	SW	O	
E. histrio Jordan & Gilbert, harlequin darter	S	R	
E. maculatum Kirtland, spotted darter	C	R	SC
E. microperca Jordan & Gilbert, least darter	N	C	
E. nigrum Rafinesque, johnny darter	I	A	
E. proeliare (Hay), cypress darter	SW	R	
E. spectabile (Agassiz), orangethroat darter	C	A	
E. squamiceps Jordan, spottail darter	SW	R	SC
E. tippecanoe Jordan & Evermann, Tippecanoe darter	C	R	SC
E. variatum Kirtland, variegate darter	SE	R	SC
E. zonale (Cope), banded darter	NW, SE	C	
Perca flavescens (Mitchill), yellow perch	N	C	
Percina caprodes (Rafinesque), logperch	I	C	
P. copelandi (Jordan), channel darter	C	R	ST
P. evides (Jordan & Copeland), gilt darter	C	O	SE

Table 1.—Continued.

	Range	Relative abundance	Status
P. maculata (Girard), blackside darter	I	C	
P. phoxocephala (Nelson), slenderhead darter	C	C	
P. sciera (Swain), dusky darter	C	C	
P. shumardi (Girard), river darter	C, S	O	
P. vigil (Hay), saddleback darter	SW	R	
Sander canadense (Griffith & Smith), sauger	W, S	C	
S. vitreus (Mitchill), walleye	I	C	
Family Sciaenidae (drum)			
Aplodinotus grunniens Rafinesque, freshwater drum	I	C	
Family Gobiidae			
Neogobius melanostomus (Pallas), round goby	NW	A	X
Extirpated:			
Atractosteus spatula (Lacepède), alligator gar	S	1976	Ex
Alosa alabamae Jordan & Evermann, Alabama shad	SW	1902	Ex
Notropis anogenus Forbes, pugnose shiner	NE	1945	Ex
N. ariommus (Cope), popeye shiner	WC	1894	Ex
Coregonus nigripinnis (Gill), blackfin cisco	NW	?	Ex
C. reighardi (Koelz), shortnose cisco	NW	1972	Ex
Esox masquinongy Mitchill, Great Lakes muskellunge	N	1910	Ex
Esox masquinongy from the Great Lakes is extirpated, but another Ohio River form of questionable status exists.			
Lagochila lacera Jordan & Brayton, harelip sucker	C	1893	Ex
Crystallaria asprella Jordan, crystal darter	S	1892–95	Ex
Percina uranidea (Jordan & Gilbert), stargazing darter	SW	1920	Ex
Despite past confusion between the two species *Percina uranidea* and *P. vigil,* the two species did occur in Indiana (but are now extirpated; C. Gilbert, pers. comm.). Thompson & Cashner (1980) showed two records for *P. uranidea* from Indiana and a single record for *P. vigil* (as former name *P. ouachitae*) in the 1980 Atlas of North American Freshwater Fishes (Lee et al. 1980).			
CLASS AMPHIBIA			
Order Caudata (salamanders)			
Family Cryptobranchidae (hellbenders)			
Crytobranchus alleganiensis (Daudin), hellbender	S	R	SE, FC

Table 1.—Continued.

	Range	Relative abundance	Status
Family Proteidae (mudpuppies)			
Necturus maculosus (Rafinesque), mudpuppy	I	O	SC
Family Ambystomatidae (mole salamanders)			
Ambystoma barbouri Kraus & Petranka, streamside salamander	SE	C	
A. jeffersonianum (Green), Jefferson's salamander	SC	O	
A. laterale Hallowell, blue-spotted salamander	N	O	SC
A. maculatum (Shaw), spotted salamander	I	C	
A. opacum (Gravenhorst), marbled salamander	C, S	C	
A. texanum (Matthes), smallmouth salamander	I	A	
A. tigrinum (Green), tiger salamander	I	C	
Family Salamandridae (newts)			
Notophthalmus viridescens (Rafinesque), eastern newt	I	O	
Family Plethodontidae (lungless salamanders)			
Aneides aeneus (Cope & Packard), green salamander	SE	R	SE
Desmognathus fuscus (Green), northern dusky salamander	SE	O	
Eurycea cirrigera (Green), two-lined salamander	C, S	A	
E. longicauda (Green), longtail salamander	S	C	
E. lucifuga Rafinesque, cave salamander	S	C	
Hemidactylium scutatum (Schlegel), four-toed salamander	N, C	R	ST
Plethodon cinereus (Green), redback salamander	I	A	
P. dorsalis Cope, zigzag salamander	C, S	C	
P. glutinosus (Green), slimy salamander	S, C	C	
P. richmondi Netting & Mittleman, ravine salamander	SE	O	
Pseudotriton ruber (Sonnini), northern red salamander	SC	R	SE
Family Sirenidae (sirens)			
Siren intermedia LeConte, lesser siren	W	O	
Order Anura (toads and frogs)			
Family Pelobatidae (spadefoot toads)			
Scaphiopus holbrookii (Harlan), eastern spadefoot	S	O	
Family Bufonidae (toads)			
Bufo americanus Holbrook, American toad	N, C, SE	C	
B. fowleri Hinkley, Fowler's toad	I	C	
Family Hylidae (tree frogs)			
Acris crepitans Baird, cricket frog	I	C	
Hyla chrysoscelis Cope, Cope's gray tree frog	I	A	
H. versicolor LeConte, eastern gray treefrog	I	A	

Table 1.—Continued.

	Range	Relative abundance	Status
Pseudacris crucifer Wied, spring peeper	I	C	
P. triseriata (Wied), western chorus frog	I	A	
Family Ranidae (true frogs)			
Rana areolata Baird & Girard, crawfish frog	W	O	ST
R. blairi Mecham et al., plains leopard frog	W	R	SC
R. clamitans Latreille, green frog	I	C	
R. catesbeiana Shaw, bullfrog	I	A	
R. pipiens Schreber, northern leopard frog	N, E	C	SC
R. palustris LeConte, pickerel frog	E, C, WC	O	
R. utricularia Harlan, southern leopard frog	S, C	C	
R. sylvatica LeConte, wood frog	I	O	
Hypothetical			
Gyrinophilus porphyriticus (Green), spring salamander			
Pseudacris brachyphona (Cope), mountain chorus frog			
Pseudotriton montanus Baird, mud salamander			
Gastrophryne carolinensis (Holbrook), eastern narrowmouth toad			
Hyla cinerea (Schneider), green treefrog			
H. avivoca Viosca, bird-voiced treefrog			
CLASS REPTILIA			
Order Testudines (turtles)			
Family Chelydridae (snapping turtles)			
Chelydra serpentina Linnaeus, common snapping turtle	I	A	
Macroclemys temminckii (Troost), alligator snapping turtle	SW	R	SE
Family Kinosternidae (musk and mud turtles)			
Kinosternon subrubrum (Lacepede), eastern mud turtle	NW, SW	R	ST
Sternotherus odoratus (Latreille), common musk turtle	I	A	
Family Emydidae (box and water turtles)			
Chrysemys picta (Schneider), painted turtle	I	A	
Clemmys guttata (Schneider), spotted turtle	N	O	ST
Emydoidea blandingii (Holbrook), Blanding's turtle	N	O	SC
Graptemys geographica (LeSueur), map turtle	I	C	
G. pseudogeographica (Gray), false map turtle	W, S	O	
G. ouachitensis Cagle, Ouachita map turtle			
Pseudemys concinna (LeConte), river cooter	SW	1950	
Terrapene carolina (Linnaeus), eastern box turtle	I	C	
T. ornata (Agassiz), ornate box turtle	NW, SW	O	SC
Trachemys scripta (Schoepff), red-eared turtle	S, W	C	

Table 1.—Continued.

	Range	Relative abundance	Status
Family Trionychidae (softshell turtles)			
Apalone mutica LeSueur, smooth softshell	W, S	O	
A. spinifera (LeSueur), spiny softshell	I	C	
Order Squamata (lizards and snakes)			
Family Iguanidae (iguanids)			
Sceloporus undulatus Latreille, eastern fence lizard	S	C	
Family Anguidae (glass lizards)			
Ophisaurus attenuatus Cope, slender glass lizard	NW	R	
Family Teiidae (whiptails)			
Cnemidophorus sexlineatus (Linnaeus), six-lined racerunner	NW, SW	O	
Family Scincidae (skinks)			
Eumeces fasciatus (Linnaeus), five-lined skink	I	C	
E. laticeps (Schneider), broad-headed skink	C, S	O	
Scincella lateralis (Say), ground skink	S	O	
Family Colubridae (common snakes)			
Carphophis amoenus (Say), worm snake	S	O	
Cemophora coccinea (Blumenbach), scarlet snake	S	R	ST
Coluber constrictor Linnaeus, black racer	I	C	
Clonophis kirtlandii (Kennicott), Kirtland's snake	N, C, SE	O	ST, FC
Diadophis punctatus (Linnaeus), northern ringneck snake	S	O	
Elaphe obsoleta (Say), black rat snake	I	C	
E. vulpina (Baird & Girard), western fox snake	NW	C	
Heterodon platirhinos Latreille, eastern hognose snake	I	C	
Lampropeltis calligaster (Harlan), prairie kingsnake	W	O	
L. getulus (Linnaeus), common kingsnake	S	O	
L. triangulum (Lacepède), eastern milksnake	I	C	
Nerodia erythrogaster (Forster), northern copperbelly	SW, NE, SC	O	ST, FC
N. rhombifer (Hallowell), diamondback water snake	SW	O	
N. sipedon (Linnaeus), banded water snake	I	A	
Opheodrys aestivus (Linnaeus), rough green snake	S	O	SC
O. vernalis (Harlan), smooth green snake	NW	R	ST
Pituophis catenifer (Blainville), bull snake	NW, SW	O	
Regina septemvittata (Say), queen snake	E, C, WC, N	C	
Storeria dekayi (Holbrook), brown snake	I	C	

Table 1.—Continued.

	Range	Relative abundance	Status
S. occipitomaculata (Storer), red-bellied snake	I	O	
Tantilla coronata (Baird & Girard), crowned snake	S	R	ST
Thamnophis butleri (Cope), Butler's garter snake	NE, C	R	ST
T. proximus (Say), western ribbon snake	NW, SW	O	SC
T. radix (Baird & Girard), plains garter snake	NW	O	
T. sauritus (Linnaeus), eastern ribbon snake	I	O	
T. sirtalis (Linnaeus), common garter snake	I	A	
Virginia valeriae Baird & Girard, western earth snake	S	O	
Family Crotalidae (pit vipers)			
Agkistrodon contortrix (Linnaeus), northern copperhead	S, WC	O	
A. piscivorus Lacepede, cottonmouth	S	R	ST
Crotalus horridus Linnaeus, timber rattlesnake	S	R	ST
Sistrurus catenatus (Rafinesque), eastern massasauga	N	R	ST, FC
Hypothetical:			
Eumeces anthracinus (Baird), coal skink			
Regina grahami Baird & Girard, Graham's water snake			
Tropidoclonian lineatum (Hallowell), lined snake			
Extirpated:			
Farancia abacura (Holbrook), mud snake	X	1894	Ex
CLASS MAMMALIA			
Order Didelphimorphia (American opossums)			
Family Didelphidae (opossums)			
Didelphis virginiana Kerr, opossum	I	A	
Order Insectivora (shrews and moles)			
Family Soricidae (shrews)			
Blarina brevicauda (Say), short-tailed shrew	I	A	
Cryptotis parva (Say), least shrew	I	O	
Sorex cinereus Kerr, masked shrew	N	C	
S. fumeus Miller, smoky shrew	SC	O	
S. hoyi Baird, pygmy shrew	SC	O	
S. longirostris Bachman, southeastern shrew	S	O	
Family Talpidae (moles)			
Condylura cristata (Rafinesque), star-nosed mole	NE	R	SC
Scalopus aquaticus (Linnaeus), eastern mole	I	A	

Table 1.—Continued.

	Range	Relative abundance	Status
Order Chiroptera (bats)			
Family Vespertilionidae (vespertilionid bats)			
Eptesicus fuscus (Beauvois), big brown bat	I	A	
Lasionycteris noctivagans (LeConte), silver-haired bat	I	O	
Lasiurus borealis (Muller), red bat	I	A	
L. cinereus (Beauvois), hoary bat	I	O	
Myotis austroriparius (Rhoads), southeastern myotis	SC	R	SE
M. grisescens (Howell), gray myotis	S	R	FE
M. lucifugus (LeConte), little brown myotis	I	C	
M. septentrionalis Trouessart, Northern myotis	I	C	
M. sodalis Miller & Allen, Indiana myotis	I	O	FE
Nycticeius humeralis (Rafinesque), evening bat	S	O	FE
Pipistrellus subflavus (Cuvier), eastern pipistrelle	S	C	
Corynorhinus rafinesquii (Lesson), Rafinesque's big-eared bat	SC	R	SC
Order Lagomorpha (rabbits, hares, and pikas)			
Family Leporidae (rabbits and hares)			
Sylvilagus aquaticus (Bachman), swamp rabbit	SW	R	SE
S. floridanus (Allen), cottontail rabbit	I	A	
Order Rodentia (rodents)			
Family Sciuridae (squirrels)			
Glaucomys volans (Linnaeus), southern flying squirrel	I	C	
Marmota monax (Linnaeus), woodchuck	I	C	
Sciurus carolinensis Gmelin, gray squirrel	I	C	
S. niger Linnaeus, fox squirrel	I	A	
Spermophilus franklinii (Sabine), Franklin's ground squirrel	NW	R	SE
S. tridecemlineatus (Mitchill), thirteen-lined ground squirrel	N	C	
Tamias striatus (Linnaeus), eastern chipmunk	I	A	
Tamiasciurus hudsonicus (Erxleben), red squirrel	N	C	
Family Geomyidae (pocket gophers)			
Geomys bursarius (Shaw), plains pocket gopher	NW	C	SC
Family Castoridae (beavers)			
Castor canadensis Kuhl, beaver	I	C	reintroduced
The beaver was extirpated by 1900 but was reintroduced.			

Table 1.—Continued.

	Range	Relative abundance	Status
Family Muridae (rats, voles, and mice)			
Subfamily Sigmodontinae			
Neotoma magister (Baird), Allegheny woodrat	SC	R	SE
Peromyscus leucopus (Rafinesque), white-footed mouse	I	A	
P. maniculatus (Wagner), deer mouse	I	C	
Reithrodontomys megalotis (Baird), western harvestmouse	NW	C	
Subfamily Arvicolinae			
Microtus ochrogaster (Wagner), prairie vole	I	C	
M. pennsylvanicus (Ord), meadow vole	I	C	
M. pinetorum (LeConte), woodland vole	I	O	
Ondatra zibethicus (Linnaeus), muskrat	I	A	
Synaptomys cooperi Baird, southern bog lemming	I	O	
Subfamily Murinae			
Mus musculus Linnaeus, house mouse	I	A	X
Rattus norvegicus (Berkenhout), Norway rat	I	A	X
The black rat, *Rattus rattus*, was extirpated about 1845 but is not included above because it was not native.			
Family Dipodidae (Zapodinae) (jumping mice)			
Zapus hudsonius (Zimmermann), meadow jumping mouse	I	O	
Order Carnivora (carnivores)			
Family Canidae (canids)			
Canis latrans Say, coyote	I	C	
Urocyon cinereoargenteus (Schreber), gray fox	I	O	
Vulpes vulpes (Linnaeus), red fox	I	O	
Family Procyonidae (raccoons and allies)			
Procyon lotor (Linnaeus), raccoon	I	A	
Family Mustelidae (weasels, badger, otter)			
Lutra canadensis (Schreber), river otter	I	R	reintroduced
The river otter became extirpated in 1942, but was reintroduced between 1995 and 1999.			
Mustela frenata Lichtenstein, long-tailed weasel	I	O	
M. nivalis (Linnaeus), least weasel	N	R	SC
M. vison Schreber, mink	I	O	
Taxidea taxus (Schreber), badger	I	R	ST

Table 1.—Continued.

	Range	Relative abundance	Status
Family Mephitidae (skunks)			
Mephitis mephitis (Schreber), striped skunk	I	C	
Family Felidae (cat)			
Lynx rufus (Schreber), bobcat	I	R	SE
Order Artiodactyla			
Family Cervidae (deer)			
Odocoileus virginianus (Zimmermann), white-tailed deer	I	A	reintroduced
The white-tailed deer was extirpated by 1900 but was reintroduced			
Hypothetical			
Myotis leibi (Audubon & Bachman), Leib's bat			
Reithrodontomys humulis (Audubon & Bachman), eastern harvest mouse			
Extirpated			
Bison bison (Linnaeus), bison	Ex (1830)		
Canis lupus Linnaeus, timber (gray) wolf	Ex (1908)		
C. rufus (Audubon & Bachman), red wolf	Ex (1832)		
Cervus elaphus Linnaeus, elk (wapiti)	Ex (1839)		
Erethizon dorsatum (Linnaeus), porcupine	Ex (1918)		
Felis concolor Linnaeus, mountain lion	Ex (1851)		
Gulo gulo (Linnaeus), wolverine	Ex (1852)		
Lynx lynx Kerr, lynx	Ex (1832?)		
Martes pennanti (Erxleben), fisher	Ex (1859)		
Spilogale putorius (Linnaeus), eastern spotted skunk	Ex (1920?)		
Ursus americanus Pallas, black bear	Ex (1850)		

Table 2.—Checklist of the birds of Indiana. Range is indicated as statewide (I), north (N), south (S), west (W), east (E), and central (C), and various combinations. General abundance is listed roughly as abundant (A), common (C), occasional (O), and rare (R). Seasonal occurrence is given as summer resident (S), winter resident (W), migrant (M), accidental (A), hypothetical (H), and breeder (*), and former breeder [(*)]. Status is listed as federally endangered (FE), federally threatened (FT), and candidates for federal listing (FC). State designations are endangered (SE), threatened (ST), and special concern (SC). Exotic or introduced species are indicated by "X." Extirpated species are listed with approximate date of disappearance.

	Range	Relative abundance	Season	Status
CLASS AVES				
Order Gaviiformes (loons)				
Family Gaviidae (loons)				
Gavia adamsii (Gray), yellow-billed loon	I	R	A	
G. immer (Brunnich), common loon	I	C	M(*)	
G. pacifica (Lawrence), pacific loon	I	R	A	
G. stellata (Pontoppidan), red-throated loon	I	O	M	
Order Podicipediformes (grebes)				
Family Podicipedidae (grebes)				
Aechmophorus occidentalis (Lawrence), western grebe	I	R	A	
Podiceps auritus (Linnaeus), horned grebe	I	O	W(*)	
P. grisegena (Boddaert), red-necked grebe	I	R	A	
P. nigricollis Brehm, eared grebe	I	R	A	
Podilymbus podiceps (Linnaeus), pied-billed grebe	I	C	R*	
Order Procellariiformes (tube-nosed swimmers)				
Family Hydrobatidae (storm-petrels)				
Oceanodroma castro (Harcourt), band-rumped storm-petrel	I	R	A	
Order Pelecaniformes (totipalmate swimmers)				
Family Sulidae (boobies and gannets)				
Morus bassanus (Linnaeus), northern gannet	I	R	A	
Family Pelecanidae (pelicans)				
Pelecanus erythrorhynchos Gmelin, American white pelican	I	R	A	
P. occidentalis Linnaeus, brown pelican	I	R	A	
Family Phalacrocoracidae (cormorants)				
Phalacrocorax auritus (Lesson), double-crested cormorant	I	O	M*	
Family Fregatidae (frigatebirds)				
Fregata magnificens Mathews, magnificent frigatebird	I	R	A	
Order Ciconiiformes (herons, ibises, storks, and allies)				
Family Ardeidae (bitterns and herons)				
Ardea alba (Linnaeus), great egret	I	O	S*	SC
Ardea herodias Linnaeus, great blue heron	I	C	R*	
Botaurus lentiginosus (Rackett), American bittern	I	R	S*	SE
Bubulcus ibis (Linnaeus), cattle egret	I	R	M*	

Table 2.—Continued.

	Range	Relative abundance	Season	Status
Butorides virescens (Linnaeus), green heron	I	C	S*	
Egretta caerulea (Linnaeus), little blue heron	I	R	S*	
E. rufescens (Gmelin), reddish egret	I	R	A	
E. thula (Molina), snowy egret	I	R	A*	
E. tricolor (Müller), tricolored heron	I	R	A	
Ixobrychus exilis (Gmelin), least bittern	I	R	S*	SE
Nyctanassa violacea (Linnaeus), yellow-crowned night-heron	S	R	S*	SE
Nycticorax nycticorax (Linnaeus), black-crowned night-heron	I	R	S*	SE
Family Threskiornithidae (ibises)				
Eudocimus albus (Linnaeus), white ibis	S	R	A	
Plegadis chihi (Vieillot), white-faced ibis	I	R	A	
P. falcinellus (Linnaeus), glossy ibis	I	R	A	
Family Ciconiidae (storks)				
Mycteria americana Linnaeus, wood stork	S	R	A	FE
Family Cathartidae (American vultures)				
Cathartes aura (Linnaeus), turkey vulture	I	C	R*	
Coragyps atratus (Bechstein), black vulture	S	R	R*	
Order Anseriformes (swans, geese, and ducks)				
Family Anatidae (swans, geese and ducks)				
Aix sponsa (Linnaeus), wood duck	I	C	R*	
Anas acuta Linnaeus, northern pintail	I	O	M*	
A. americana Gmelin, American wigeon	I	O	M(*)	
A. clypeata Linnaeus, northern shoveler	I	O	M*	
A. crecca (Linnaeus), green-winged teal	I	O	M*	
A. cyanoptera Viellot, cinnamon teal	I	R	A	
A. discors Linnaeus, blue-winged teal	I	O	S*	
A. penelope Linnaeus, Eurasian wigeon	I	R	A	
A. platyrhynchos Linnaeus, mallard	I	C	R*	
A. rubripes Brewster, American black duck	I	C	R*	
A. strepera Linnaeus, gadwall	I	O	M*	
Anser albifrons (Scopoli), greater white-fronted goose	I	R	M	

Table 2.—Continued.

	Range	Relative abundance	Season	Status
Aythya affinis (Eyton), lesser scaup	I	C	W(*)	
A. americana (Eyton), redhead	I	O	M*	
A. collaris (Donovan), ring-necked duck	I	O	M*	
A. marila (Linnaeus), greater scaup	N	O	W	
A. valisineria (Wilson), canvasback	I	O	M	
Branta bernicla (Linnaeus), brant	N	R	A	
B. canadensis (Linnaeus), Canada goose	I	A	R*	
Bucephala albeola (Linnaeus), bufflehead	I	O	W	
B. clangula (Linnaeus), common goldeneye	I	C	W	
B. islandica (Gmelin), Barrow's goldeneye	N	R	A	
Chen caerulescens (Linnaeus), snow goose	I	O	M	
C. rossii (Cassin), Ross's goose	I	R	A	
Clangula hyemalis (Linnaeus), long-tailed duck	N	O	W	
Cygnus buccinator Richardson, trumpeter swan	I	R	W(*)	SE
C. columbianus (Ord), tundra swan	I	O	M	
C. olor (Gmelin), mute swan	I	O	R*	X
Dendrocygna bicolor (Vieillot), fulvous whistling-duck	I	R	A	
Histrionicus histrionicus (Linnaeus), harlequin duck	N	R	A	
Lophodytes cucullatus (Linnaeus), hooded merganser	I	O	R*	
Melanitta fusca (Linnaeus), white-winged scoter	N	R	M	
M. nigra (Linnaeus), black scoter	N	R	M	
M. perspicillata (Linnaeus), surf scoter	N	R	M	
Mergus merganser Linnaeus, common merganser	I	O	W	
M. serrator Linnaeus, red-breasted merganser	I	O	M*	
Oxyura jamaicensis (Gmelin), ruddy duck	I	O	M*	
Somateria spectabilis (Linnaeus), king eider	N	R	A	
Order Falconiformes (diurnal birds of prey)				
Family Accipitridae (kites, eagles, hawks, and allies)				
Accipiter cooperii (Bonaparte), Cooper's hawk	I	O	R*	
A. gentilis (Linnaeus), northern goshawk	N	R	W	
A. striatus Vieillot, sharp-shinned hawk	I	O	R*	SC
Aquila chrysaetos (Linnaeus), golden eagle	I	R	M	
Buteo jamaicensis (Gmelin), red-tailed hawk	I	A	R*	

Table 2.—Continued.

	Range	Relative abundance	Season	Status
B. lagopus (Pontoppidan), rough-legged hawk	I	O	W	
B. lineatus (Gmelin), red-shouldered hawk	I	O	R*	SC
B. playpterus (Vieillot), broad-winged hawk	I	O	S*	SC
B. regalis (Gray), ferruginous hawk	W	R	A	
B. swainsoni Bonaparte, Swainson's hawk	W	R	A	
Circus cyaneus (Linnaeus), northern harrier	I	O	R*	SE
Elanoides forficatus (Linnaeus), swallow-tailed kite	I	R	A(*)	
Elanus leucurus (Vieillot), white-tailed kite	I	R	A	
Family Falconidae (falcons)				
Falco columbarius Linnaeus, merlin	I	R	M	
F. mexicanus Schlegel, prairie falcon	W	R	A	
F. peregrinus Tunstall, peregrine falcon	I	R	R*	SE
F. rusticolus Linnaeus, gyrfalcon	N	R	A	
F. sparverius Linnaeus, American kestrel	I	C	R*	
Haliaeetus leucocephalus (Linnaeus), bald eagle	I	R	R*	SE, FT
Ictinia mississippiensis (Wilson), Mississippi kite	I	R	A*	SC
Pandion haliaetus (Linnaeus), osprey	I	R	S*	SE
Order Galliformes (gallinaceous birds)				
Family Phasianidae (grouse, turkey, and quail)				
Bonasa umbellus (Linnaeus), ruffed grouse	S	O	R*	
Meleagris gallopavo Linnaeus, wild turkey	I	O	R*	
Phasianus colchicus Linnaeus, ring-necked pheasant	N	O	R*	X
Family Odontophoridae (quail)				
Colinus virginianus (Linnaeus), northern bobwhite	I	C	R*	
Order Gruiformes (cranes, rails, and allies)				
Family Rallidae (rails, gallinules, and coots)				
Coturnicops noveboracensis (Gmelin), yellow rail	I	R	M	
Fulica americana (Gmelin), American coot	I	O	R*	
Gallinula chloropus (Linnaeus), common moorhen	I	R	S*	
Laterallus jamaicensis (Gmelin), black rail	I	R	A*	SE
Porphyrio martinica (Linnaeus), purple gallinule	I	R	A	
Porzana carolina (Linnaeus), sora	I	O	S*	
Rallus elegans Audubon, king rail	I	R	S*	SE
R. limicola Vieillot, Virginia rail	I	R	R*	SE
Family Gruidae (cranes)				
Grus canadensis (Linnaeus), sandhill crane	I	O	M*	SC

Table 2.—Continued.

	Range	Relative abundance	Season	Status
G. grus (Linnaeus), common crane	I	R	A	
Order Charadriiformes (shorebirds, gulls, auks, and allies)				
Family Charadriidae (plovers)				
Charadrius alexandrinus Linnaeus, snowy plover	I	R	A	
C. melodus Ord, piping plover	I	R	A(*)	SE, FE
C. semipalmatus Bonaparte, semipalmated plover	I	O	M	
C. vociferus Linnaeus, killdeer	I	C	R*	
C. wilsonia Ord, Wilson's plover	I	R	A	
Pluvialis dominica (Müller), American golden-plover	I	O	M	
P. squatarola (Linnaeus), black-bellied plover	I	O	M	
Family Recurvirostridae (stilts and avocets)				
Himantopus mexicanus (Müller), black-necked stilt	I	R	A	
Recurvirostra americana Gmelin, American avocet	I	R	M(*)	
Family Scolopacidae (sandpipers, phalaropes, and allies)				
Actitis macularia (Linnaeus), spotted sandpiper	I	O	S*	
Arenaria interpres (Linnaeus), ruddy turnstone	I	R	M	
Bartramia longicauda (Bechstein), upland sandpiper	I	R	S*	SE
Calidris acuminata (Horsfield), sharp-tailed sandpiper	I	R	A	
C. alba (Pallas), sanderling	I	R	M	
C. alpina (Linnaeus), dunlin	I	O	M	
C. bairdii (Coues), Baird's sandpiper	I	R	M	
C. canutus (Linnaeus), red knot	I	R	M	
C. ferruginea (Pontoppidan), curlew sandpiper	I	R	A	
C. fuscicollis (Vieillot), white-rumped sandpiper	I	R	M	
C. himantopus (Bonaparte), stilt sandpiper	I	R	M	
C. maritima (Brünnich), purple sandpiper	I	R	W	
C. mauri (Cabanis), western sandpiper	I	O	M	
C. melanotos (Vieillot), pectoral sandpiper	I	O	M	
C. minutilla (Vieillot), least sandpiper	I	O	M	
C. pusilla (Linnaeus), semipalmated sandpiper	I	O	M	
Catoptrophorus semipalmatus (Gmelin), willet	I	R	M	
Gallinago delicata (Ord), Wilson's snipe	I	O	R*	
Limnodromus griseus (Gmelin), short-billed dowitcher	I	O	M	
L. scolopaceus (Say), long-billed dowitcher	I	O	M	

Table 2.—Continued.

	Range	Relative abundance	Season	Status
Limosa fedoa (Linnaeus), marbled godwit	I	R	A	
L. haemastica (Linnaeus), Hudsonian godwit	I	R	A	
Numenius phaeopus (Linnaeus), whimbrel	I	R	M	
Phalaropus fulicarius (Linnaeus), red phalarope	I	R	M	
P. lobatus (Linnaeus), red-necked phalarope	I	R	M	
P. tricolor (Vieillot), Wilson's phalarope	I	R	M(*)	
Philomachus pugnax (Linnaeus), ruff	I	R	A	
Scolopax minor Gmelin, American woodcock	I	O	S*	
Tringa flavipes (Gmelin), lesser yellowlegs	I	O	M	
T. melanoleuca (Gmelin), greater yellowlegs	I	O	M	
T. solitaria Wilson, solitary sandpiper	I	O	M	
Tryngites subruficollis (Vieillot), buff-breasted sandpiper	I	R	M	
Family Laridae (jaegers, gulls, terns, and skimmers)				
Chlidonias leucopterus (Temminck), white-winged tern	N	R	A	
C. niger (Linnaeus), black tern	I	O	S*	SE
Larus argentatus Pontoppidan, herring gull	I	C	R*	
L. atricilla Linnaeus, laughing gull	I	R	M	
L. californicus Lawrence, California gull	I	R	A	
L. canus Linnaeus, mew gull	I	R	A	
L. delawarensis Ord, ring-billed gull	I	C	R*	
L. fuscus Linnaeus, lesser black-backed gull	I	R	A	
L. glaucoides Meyer, Iceland gull	I	R	A	
L. hyperboreus Gunnerus, glaucous gull	I	R	W	
L. marinus Linnaeus, great black-backed gull	I	R	M	
L. minutus Pallas, little gull	I	R	A	
L. philadelphia (Ord), Bonaparte's gull	I	O	M	
L. pipixcan Wagler, Franklin's gull	I	R	M	
L. ridibundus Linnaeus, black-headed gull	I	R	A	
L. schistisagus Stejneger, slaty-backed gull	I	R	A	
L. thayeri Brooks, Thayer's gull	I	R	M	
Rhodostethia rosea (MacGillivray), Ross's gull	I	R	A	
Rissa tridactyla (Linnaeus), black-legged kittiwake	I	R	A	
Rynchops niger Linnaeus, black skimmer	I	R	A	
Stercorarius longicaudus Vieillot, long-tailed jaeger	N	R	M	

Table 2.—Continued.

	Range	Relative abundance	Season	Status
S. parasiticus (Linnaeus), parasitic jaeger	N	R	M	
S. pomarinus (Temminck), pomarine jaeger	N	R	M	
Sterna antillarum (Lesson), least tern	I	R	S*	SE, FE
S. caspia Pallas, Caspian tern	I	O	M*	
S. dougallii Montagu, roseate tern	I	R	A	FE
S. forsteri Nuttall, Forster's tern	I	O	M(*)	
S. fuscata Linnaeus, sooty tern	I	R	A	
S. hirundo Linnaeus, common tern	I	O	M(*)	
S. maxima Boddaert, royal tern	I	R	A	
S. nilotica Gmelin, gull-billed tern	I	R	A	
S. paradisaea Pontoppidan, arctic tern	I	R	A	
Xema sabini (Sabine), Sabine's gull	I	R	A	
Family Alcidae (auks, murres, and puffins)				
Brachyramphus perdix (Pallas), long-billed murrelet	I	R	A	
Synthliboramphus antiquus (*Gmelin*), ancient murrelet	I	R	A	
Uria lomvia (Linnaeus), thick-billed murre	I	R	A	
Order Columbiformes (pigeons and doves)				
Family Columbidae (pigeons and doves)				
Columba fasciata Say, band-tailed pigeon	I	R	A	
C. livia Gmelin, rock dove	I	A	R*	X
Columbina passerina (Linnaeus), common ground-dove	I	R	A	
Streptopelia decaocto (Frivaldsky), Eurasian collared-dove	I	R	R*	X
Zenaida asiatica (Linnaeus), white-winged dove	I	R	A	
Z. macroura (Linnaeus), mourning dove	I	A	R*	
Order Cuculiformes (cuckoos)				
Family Cuculidae (cuckoos)				
Coccyzus americanus (Linnaeus), yellow-billed cuckoo	I	O	S*	
C. erythrophthalmus (Wilson), black-billed cuckoo	I	O	S*	
Crotophaga sulcirostris Swainson, groove-billed ani	I	R	A	
Order Strigiformes (owls)				
Family Tytonidae (barn owls)				
Tyto alba (Scopoli), barn owl	I	R	R*	SE
Family Strigidae (typical owls)				
Aegolius acadicus (Gmelin), northern saw-whet owl	I	R	W*	
Asio flammeus (Pontoppidan), short-eared owl	I	R	R*	SE
A. otus (Linnaeus), long-eared owl	I	R	R*	
Athene cunicularia (Molina), burrowing owl	W	R	A	

Table 2.—Continued.

	Range	Relative abundance	Season	Status
Bubo virginianus (Gmelin), great horned owl	I	C	R*	
Nyctea scandiaca (Linnaeus), snowy owl	N	R	W	
Otus asio (Linnaeus), eastern screech-owl	I	C	R*	
Strix varia Barton, barred owl	I	O	R*	
Order Caprimulgiformes (goatsuckers, oilbirds, and allies)				
Family Caprimulgidae (goatsuckers)				
Caprimulgus carolinensis Gmelin, chuck-will's-widow	S	R	S*	
C. vociferus Wilson, whip-poor-will	I	C	S*	
Chordeiles minor (Forster), common nighthawk	I	O	S*	
Order Apodiformes (swifts and hummingbirds)				
Family Apodidae (swifts)				
Chaetura pelagica (Linnaeus), chimney swift	I	A	S*	
Family Trochilidae (hummingbirds)				
Archilochus colubris (Linnaeus), ruby-throated hummingbird	I	C	S*	
Selasphorus rufus (Gmelin), rufous hummingbird	I	R	A	
Order Coraciiformes (todies, motmots, and kingfishers)				
Family Alcedinidae (kingfishers)				
Ceryle alcyon (Linnaeus), belted kingfisher	I	O	R*	
Order Piciformes (woodpeckers and allies)				
Family Picidae (woodpeckers)				
Colaptes auratus (Linnaeus), northern flicker	I	C	R*	
Dryocopus pileatus (Linnaeus), pileated woodpecker	I	O	R*	
Melanerpes carolinus (Linnaeus), red-bellied woodpecker	I	C	R*	
M. erythrocephalus (Linnaeus), red-headed woodpecker	I	O	R*	
Picoides arcticus (Swainson), black-backed woodpecker	N	R	A	
P. pubescens (Linnaeus), downy woodpecker	I	C	R*	
P. villosus (Linnaeus), hairy woodpecker	I	C	R*	
Sphyrapicus varius (Linnaeus), yellow-bellied sapsucker	I	R	M*	
Order Passeriformes (passerine birds)				
Family Tyrannidae (flycatchers)				
Contopus cooperi (Nuttall), olive-sided flycatcher	I	R	M	
C. sordidulus Sclater, western wood-pewee	W	R	A	
C. virens (Linnaeus), eastern wood-pewee	I	C	S*	
Empidonax alnorum Brewster, alder flycatcher	N	R	S*	

Table 2.—Continued.

	Range	Relative abundance	Season	Status
E. flaviventris (Baird and Baird), yellow-bellied flycatcher	I	R	M	
E. minimus (Baird and Baird), least flycatcher	I	R	S*	
E. traillii (Audubon), willow flycatcher	I	O	S*	
E. virescens (Vieillot), Acadian flycatcher	I	O	S*	
Myiarchus crinitus (Linnaeus), great crested flycatcher	I	O	S*	
Pyrocephalus rubinus (Boddaert), vermilion flycatcher	I	R	A	
Sayornis phoebe (Latham), eastern phoebe	I	O	R*	
S. saya (Bonaparte), Say's phoebe	I	R	A	
Tyrannus forficatus (Gmelin), scissor-tailed flycatcher	S	R	A*	
T. tyrannus (Linnaeus), eastern kingbird	I	C	S*	
T. verticalis Say, western kingbird	I	R	A*	
Family Laniidae (shrikes)				
Lanius excubitor Linnaeus, northern shrike	N	R	W	
L. ludovicianus Linnaeus, loggerhead shrike	I	R	R*	SE, FC
Family Vireonidae (vireos)				
Vireo bellii Audubon, Bell's vireo	W	R	S*	
V. flavifrons (Vieillot), yellow-throated vireo	I	O	S*	
V. gilvus (Vieillot), warbling vireo	I	C	S*	
V. griseus (Boddaert), white-eyed vireo	I	C	S*	
V. olivaceus (Linnaeus), red-eyed vireo	I	C	S*	
V. philadelphicus (Cassin), Philadelphia vireo	I	R	M	
V. solitarius (Wilson), blue-headed vireo	I	R	M*	
Family Corvidae (jays, magpies, and crows)				
Aphelocoma californica Vigors, western scrub-jay	I	R	A	
Corvus brachyrhynchos Brehm, American crow	I	A	R*	
C. corax Linnaeus, common raven	I	R	A(*)	
C. ossifragus Wilson, fish crow	SW	R	S	
Cyanocitta cristata (Linnaeus), blue jay	I	A	R*	
Pica hudsonia (Linnaeus), black-billed magpie	I	R	A	
Family Alaudidae (larks)				
Eremophila alpestris (Linnaeus), horned lark	I	C	R*	

Table 2.—Continued.

	Range	Relative abundance	Season	Status
Family Hirundinidae (swallows)				
Hirundo rustica Linnaeus, barn swallow	I	A	S*	
Petrochelidon pyrrhonota Vieillot, cliff swallow	I	R	S*	
Progne subis (Linnaeus), purple martin	I	C	S*	
Riparia riparia (Linnaeus), bank swallow	I	O	S*	
Stelgidopteryx serripennis (Audubon), northern rough-winged swallow	I	O	S*	
Tachycineta bicolor (Vieillot), tree swallow	I	O	S*	
Family Paridae (titmice)				
Baeolophus bicolor Linnaeus, tufted titmouse	I	C	R*	
Poecile atricapilla Linnaeus, black-capped chickadee	N	C	R*	
P. carolinensis Audubon, Carolina chickadee	S	C	R*	
P. hudsonia Forster, boreal chickadee	I	R	A	
Family Sittidae (nuthatches)				
Sitta canadensis Linnaeus, red-breasted nuthatch	I	O	W*	
S. carolinensis Latham, white-breasted nuthatch	I	C	R*	
Family Certhiidae (creepers)				
Certhia americana Bonaparte, brown creeper	I	O	R*	
Family Troglodytidae (wrens)				
Cistothorus palustris (Wilson), marsh wren	I	R	S*	SE
C. platensis (Latham), sedge wren	I	R	S*	SE
Salpinctes obsoletus (Say), rock wren	I	R	A	
Thryomanes bewickii (Audubon), Bewick's wren	I	R	R*	SE
Thryothorus ludovicianus (Latham), Carolina wren	I	C	R*	
Troglodytes aedon Vieillot, house wren	I	C	S*	
T. troglodytes (Linnaeus), winter wren	I	O	W	
Family Regulidae (kinglets)				
Regulus calendula (Linnaeus), ruby-crowned kinglet	I	R	M	
R. satrapa Lichtenstein, golden-crowned kinglet	I	C	W*	
Family Sylviidae (old world warblers)				
Polioptila caerulea (Linnaeus), blue-gray gnatcatcher	I	C	S*	
Family Turdidae (thrushes)				
Catharus fuscesceus (Stephens) veery	I	O	S*	
C. guttatus (Pallas), hermit thrust	I	O	W	
C. minimus (Lafresnaye), gray-cheeked thrush	I	O	M	

Table 2.—Continued.

	Range	Relative abundance	Season	Status
C. ustulatus (Nuttall), Swainson's thrush	I	O	M	
Hylocichla mustelina (Gmelin), wood thrush	I	C	S*	
Ixoreus naevius (Gmelin), varied thrush	I	R	A	
Myadestes townsendi (Audubon), Townsend's solitaire	I	R	A	
Oenanthe oenanthe (Linnaeus), northern wheatear	I	R	A	
Sialia currucoides (Bechstein), mountain bluebird	I	R	A	
S. sialis (Linnaeus), eastern bluebird	I	C	R*	
Turdus migratorius Linnaeus, American robin	I	A	R*	
Family Mimidae (mimic thrushes)				
Dumetella carolinensis (Linaeus), gray catbird	I	C	S*	
Mimus polyglottos (Linnaeus), northern mockingbird	I	C	R*	
Toxostoma rufum (Linnaeus), brown thrasher	I	C	R*	
Family Sturnidae (starlings)				
Sturnus vulgaris Linnaeus, European starling	I	A	R*	X
Family Motacillidae (wagtails and pipits)				
Anthus rubescens (Tunstall), American pipit	I	R	M	
Family Bombycillidae (waxwings)				
Bombycilla cedrorum Vieillot, cedar waxwing	I	O	R*	
B. garrulus (Linnaeus), Bohemian waxwing	N	R	W	
Family Parulidae (new world warblers)				
Dendroica caerulescens (Gmelin), black-throated blue warbler	I	O	M	
D. castanea (Wilson), bay-breasted warbler	I	O	M	
D. cerulea (Wilson), cerulean warbler	I	O	S*	SC
D. coronata (Linnaeus), yellow-rumped warbler	I	C	W	
D. discolor (Vieillot), prairie warbler	I	O	S*	
D. dominica (Linnaeus), yellow-throated warbler	I	O	S*	
D. fusca (Müller), blackburnian warbler	I	O	M*	
D. kirtlandii (Baird), Kirtland's warbler	I	R	M	SE, FE
D. magnolia (Wilson), magnolia warbler	I	O	M*	
D. nigrescens (Townsend), black-throated gray warbler	I	R	A	
D. palmarum (Gmelin), palm warbler	I	O	M	
D. pensylvanica (Linnaeus), chestnut-sided warbler	N	O	M*	
D. petechia (Linnaeus), yellow warbler	I	C	S*	
D. pinus (Wilson), pine warbler	S	O	S*	

Table 2.—Continued.

	Range	Relative abundance	Season	Status
D. striata (Forster), blackpoll warbler	I	O	M	
D. tigrina (Gmelin), Cape May warbler	I	O	M	
D. townsendi (Townsend), Townsend's warbler	I	R	A	
D. virens (Gmelin), black-throated green warbler	I	O	S*	
Geothlypis trichas (Linnaeus), common yellowthroat	I	C	S*	
Helmitheros vermivorus (Gmelin), worm-eating warbler	I	R	S*	SC
Icteria virens (Linnaeus), yellow-breasted chat	I	C	S*	
Limnothlypis swainsonii (Audubon), Swainson's warbler	SW	R	A	
Mniotilta varia (Linnaeus), black-and-white warbler	I	O	S*	SC
Oporornis agilis (Wilson), Connecticut warbler	I	R	M	
O. formosus (Wilson), Kentucky warbler	I	O	S*	
O. philadelphia (Wilson), mourning warbler	I	R	M	
Parula americana (Linnaeus), northern parula	I	O	S*	
Protonotaria citrea (Boddaert), prothonotary warbler	I	O	S*	
Seiurus aurocapillus (Linnaeus), ovenbird	I	O	S*	
S. motacilla (Vieillot), Louisiana waterthrush	I	O	S*	
S. noveboracensis (Gmelin), northern waterthrush	I	R	S*	
Setophaga ruticilla (Linnaeus), American redstart	I	O	S*	
Vermivora celata (Say), orange-crowned warbler	I	O	M	
V. chrysoptera (Linnaeus), golden-winged warbler	I	R	S*	SE
V. peregrina (Wilson), Tennessee warbler	I	C	M	
V. pinus (Linnaeus), blue-winged warbler	I	O	S*	
V. ruficapilla (Wilson), Nashville warbler	I	O	M	
Wilsonia canadensis (Linnaeus), Canada warbler	N	R	M*	
W. citrina (Boddaert), hooded warbler	I	R	S*	SC
W. pusilla (Wilson), Wilson's warbler	I	O	M	
Family Thraupidae (tanagers)				
Piranga ludoviciana (Wilson), western tanager	W	R	A	
P. olivacea (Gmelin), scarlet tanager	I	O	S*	
P. rubra (Linnaeus), summer tanager	S	O	S*	
Family Emberizidae (new world sparrows)				
Aimophila aestivalis (Lichtenstein), Bachman's sparrow	S	R	S(*)	SE

Table 2.—Continued.

	Range	Relative abundance	Season	Status
A. cassinii (Woodhouse), Cassin's sparrow	I	R	A	
Ammodramus henslowii (Audubon), Henslow's sparrow	I	R	S*	SE
A. leconteii (Audubon), LeConte's sparrow	I	R	W	
A. nelsoni (Allen), Nelson's sharp-tailed sparrow	I	R	M	
A. savannarum (Gmelin), grasshopper sparrow	I	O	S*	
Calamospiza melanocorys Stejneger, lark bunting	I	R	A	
Calcarius lapponicus (Linnaeus), Lapland longspur	I	O	W	
C. mccownii (Lawrence), McCown's longspur	I	R	A	
C. pictus (Swainson), Smith's longspur	I	R	M	
Chondestes grammacus (Say), lark sparrow	I	R	S*	
Junco hyemalis (Linnaeus), dark-eyed junco	I	A	W	
Melospiza georgiana (Latham), swamp sparrow	I	O	R*	
M. lincolnii (Audubon), Lincoln's sparrow	I	R	M	
M. melodia (Wilson), song sparrow	I	A	R*	
Passerculus sandwichensis (Gmelin), savannah sparrow	I	O	S*	
Passerella iliaca (Merrem), fox sparrow	I	O	W	
Pipilo chlorurus (Audubon), green-tailed towhee	I	R	A	
P. erythrophthalmus (Linnaeus), eastern towhee	I	O	R*	
P. maculatus (Swainson), spotted towhee	I	R	A	
Plectrophenax nivalis (Linnaeus), snow bunting	I	O	W	
Pooecetes gramineus (Gmelin), vesper sparrow	I	O	S*	
Spizella arborea (Wilson), American tree sparrow	I	C	W	
S. pallida (Swainson), clay-colored sparrow	I	R	A	
S. passerina (Bechstein), chipping sparrow	I	C	S*	
S. pusilla (Wilson), field sparrow	I	C	R*	
Zonotrichia albicollis (Gmelin), white-throated sparrow	I	O	W	
Z. leucophrys (Forster), white-crowned sparrow	I	O	W	
Z. querula (Nuttall), Harris's sparrow	I	R	W	
Family Cardinalidae (grosbeaks)				
Cardinalis cardinalis (Linnaeus), northern cardinal	I	A	R*	

Table 2.—Continued.

	Range	Relative abundance	Season	Status
Passerina caerulea (Linnaeus), blue grosbeak	S	O	S*	
P. ciris (Linnaeus), painted bunting	I	R	A	
P. cyanea (Linnaeus), indigo bunting	I	A	S*	
Pheucticus ludovicianus (Linnaeus), rose-breasted grosbeak	I	C	S*	
P. melanocephalus (Swainson), black-headed grosbeak	I	R	A	
Spiza americana (Gmelin), dickcissel	I	O	S*	
Family Icteridae (icterines)				
Agelaius phoeniceus (Linnaeus), red-winged blackbird	I	A	R*	
Dolichonyx oryzivorus (Linnaeus), bobolink	I	O	S*	
Euphagus carolinus (Müller), rusty blackbird	I	R	W	
E. cyanocephalus (Wagler), Brewer's blackbird	W	R	M*	
Icteris galbula (Linnaeus), Baltimore oriole	I	O	S*	
I. spurius (Linnaeus), orchard oriole	I	O	S*	
Molothrus ater (Boddaert), brown-headed cowbird	I	A	R*	
Quiscalus mexicanus (Gmelin), great-tailed grackle	I	R	A	
Q. quiscula (Linnaeus), common grackle	I	A	R*	
Sturnella magna (Linnaeus), eastern meadowlark	I	A	R*	
S. neglecta (Audubon), western meadowlark	N	R	R*	SC
Xanthocephalus xanthocephalus (Bonaparte), yellow-headed blackbird	W	R	S*	SE
Family Fringillidae (finches)				
Carduelis flammea (Linnaeus), common redpoll	N	R	W	
C. hornemanni (Holböll), hoary redpoll	N	R	A	
C. pinus (Wilson), pine siskin	I	O	W*	
C. tristis (Linnaeus), American goldfinch	I	C	R*	
Carpodacus mexicanus (Müller), house finch	I	C	R*	X
C. purpureus (Gmelin), purple finch	I	O	W	
Coccothraustes vespertinus (Cooper), evening grosbeak	I	R	W	
Fringilla montifringilla Linnaeus, brambling	I	R	A	
Loxia curvirostra Linnaeus, red crossbill	N	R	W*	
L. leuceoptera Gmelin, white-winged crossbill	N	R	W	
Pinicola enucleator (Linnaeus), pine grosbeak	N	R	W	
Family Passeridae (weaver finches)				

Table 2.—Continued.

	Range	Relative abundance	Season	Status
Passer domesticus (Linnaeus), house sparrow	I	A	R*	X
P. montanus (Linnaeus), Eurasian tree sparrow	I	R	A	X
Extirpated:				
Campephilus principalis (Linnaeus), ivory-billed woodpecker	S		H(*)	FE, Ex (1814)
Conuropsis carolinensis (Linnaeus), Carolina parakeet	I		R(*)	Ex (1859)
Ectopistes migratorius (Linnaeus), passenger pigeon	I		R(*)	Ex (1902)
Grus americana (Linnaeus), whooping crane	N		M	SE, FE, Ex (1907)
Numenius borealis (Forster), eskimo curlew	I		M	FE, Ex (1890)
Perdix perdix (Linnaeus), gray partridge	N		R(*)	X, Ex (1977)
Tympanuchus cupido (Linnaeus), greater prairie-chicken	NW		R(*)	Ex (1972)
Vermivora bachmanii (Audubon), Bachman's warbler	S		H	FE, Ex (1899)

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POPULATION STUDIES ON A MATERNITY COLONY OF LITTLE BROWN BATS IN WEST-CENTRAL INDIANA

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ABSTRACT. Between 1987 and 1992 studies were conducted on a large maternity colony of little brown myotis (*Myotis lucifugus*) in a barn in Clay County near Brazil, Indiana. Evening flight counts were conducted to examine seasonal population fluctuations, and over 1700 bats were banded to determine possible use of alternative roosts and the location of winter hibernacula. In 1988 and 1989, spring buildup occurred from late March through late April. Summer counts in 1987 showed a marked increase from early to mid-July, while counts from 1989 showed a dramatic decline from late May until early July. The 1989 decline was very unusual because it continued well after parturition, and volancy of young, when the population should have been highest. Reasons for the decline are unclear, but banded bats found in a nearby colony indicate some use of alternative summer roosts. Fall counts in 1988, 1989 and 1990 found a similar rate of decline from September through October though many more bats were present in 1988. Most bats were gone by early November. Twenty-six banded bats were found at six locations in central and southern Indiana and Kentucky. Seven bats were found in summer while 19 were hibernating bats. Most relocations were within 60 km of the barn.

Keywords: Bats, little brown myotis, *Myotis lucifugus*, maternity colony, hibernation

The little brown myotis (*Myotis lucifugus*) is widely distributed in North America. It typically hibernates in caves in winter, but commonly utilizes man-made structures as maternity roosts in summer (Fenton & Barclay 1980). In central Indiana, maternity colonies typically begin to form in late March or early April and begin to disperse in late summer and early fall as bats move to fall swarming sites and hibernacula. The timing of fall migration varies with latitude, occurring as early as August in northern parts of their range in Canada and Alaska (Fenton & Barclay 1980).

Humphrey & Cope (1976) conducted flight counts in two colonies of little brown myotis in central Indiana to examine seasonal fluctuations. They noted population increases from late April into May, followed by a decline in early June. The June decline was followed by another peak in early July with the addition of volant young to the population. The fall decline began in August and continued until early October. In fall, this species moves to swarming sites in caves or mine openings. Presumably mating occurs at this time. Some bats hibernate at swarming sites, though much more information is needed about swarming and swarming sites. Eventually, bats move to winter hibernacula but little is known about the extent to which individuals from one maternity colony use the same hibernacula or disperse.

In Indiana, long-term data indicate that this species is declining, possibly due to competition with big brown bats (*Eptesicus fuscus*) for roosting sites (Whitaker et al. 2002). Cope et al. (1991) noted that little brown myotis colonies had decreased in relation to big brown bat colonies between 1959 and 1989. Presumably, these declines are not exclusive to Indiana, but their extent is unknown. More information is clearly needed on the population dynamics and movement patterns of this species.

This study was conducted on a large maternity colony to examine the pattern of population fluctuation, gather information on the use of alternative summer roosts, and determine the locations of winter hibernacula. These data were intended to provide baseline information for more extensive population studies; however, the barn that housed the col-

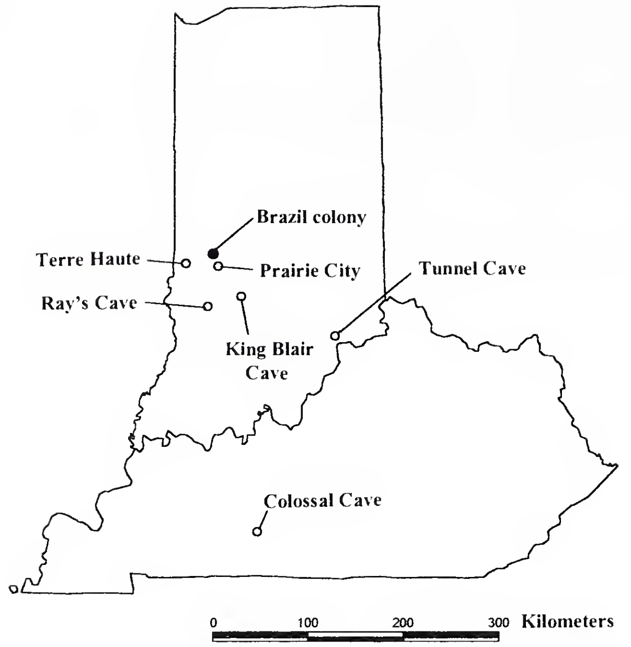

Figure 1.—Location of the barn colony at Brazil, along with the approximate locations of bats banded from the colony. Twenty six banded bats were found at six locations. Most bats were found within 60 km of the barn, although two hibernacula were well over 100 km away.

ony was torn down in 1992 and the potential for future work was lost.

METHODS

The bat colony was located in a barn approximately 8 km south of Brazil, Clay County, in west-central Indiana (Fig. 1). The surrounding landscape is a mixture of agricultural, residential and woodland areas, with a few small ponds near the barn. The colony was the largest known in Indiana with a maximum count of 6500 bats. Although no definitive data exist, indications from local accounts and the amount of guano present suggest that bats had used the barn for at least 30 years prior to 1987. Most data were collected in 1988, 1989 and 1990 and include evening flight counts and banding returns from bats banded in 1988 and 1989.

Flight counts.—Flight counts were conducted in July, October and November of 1987 and in April, September and October of 1988. Weekly flight counts were made from March–November of 1989 and from October–December 1990. A daytime count of roosting bats was made in September 1990 and two evening flight counts were made in April and July 1991.

Bats exited primarily through a large open window on the west side of the barn, from a smaller window on the east side, and from under the eaves on all sides. Two to four people were stationed at opposite corners of the barn where exits could be most clearly seen. Bats were counted as they exited at dusk. Counts were stopped when at least 10 minutes had passed without bats emerging and when visual inspection showed no, or very few, bats remaining in the barn.

Banding.—In 1988 and 1989, banding was conducted to determine locations of winter roosts and to examine the possible use of alternative roosts in summer. Bats were captured for banding using a framed wire bat trap (Tuttle 1974) or by hand as they roosted and were fitted with orange plastic forearm bands. Bats were banded in August and September 1988 and July 1989, with over 1700 bats banded in total. Information on locations of banded bats was gathered from a biennial winter search (1980 to present) of all known hibernacula in Indiana (Brack & Dunlop 1999), investigation of other known colonies, or other reported sightings. Flight count data are presented by season (spring buildup, summer patterns, and fall decline) so that the overall patterns can be examined, and differences among years discussed. Spring buildup was considered the time from the first counts to the end of buildup (March–May). Summer was the time from the end of buildup to the beginning of fall decline (June–mid August), and fall decline was the time from the beginning of decrease until no bats remained.

RESULTS

Spring buildup.—Spring counts were made in 1988, 1989 and 1991 (Fig. 2). No bats were seen on 15 or 25 March 1988, but 164 bats were counted on 9 April. On 26 April 1050 bats were counted, and an estimated 2000 bats remained in the barn when counts were stopped due to darkness. In 1989, no bats were seen on 22 March while five were counted on 29 March. Numbers increased rapidly through April and peaked at 2283 bats on 26 April 1989. Numbers dropped slightly but remained around 2000 bats throughout May. Fifty-four bats were counted on 6 April 1991.

Summer patterns.—Summer counts were made in 1987, 1989 and 1991 (Fig. 3). In 1987, 2180 bats were counted on 7 July and 6500 on 15 July. The most extensive counts

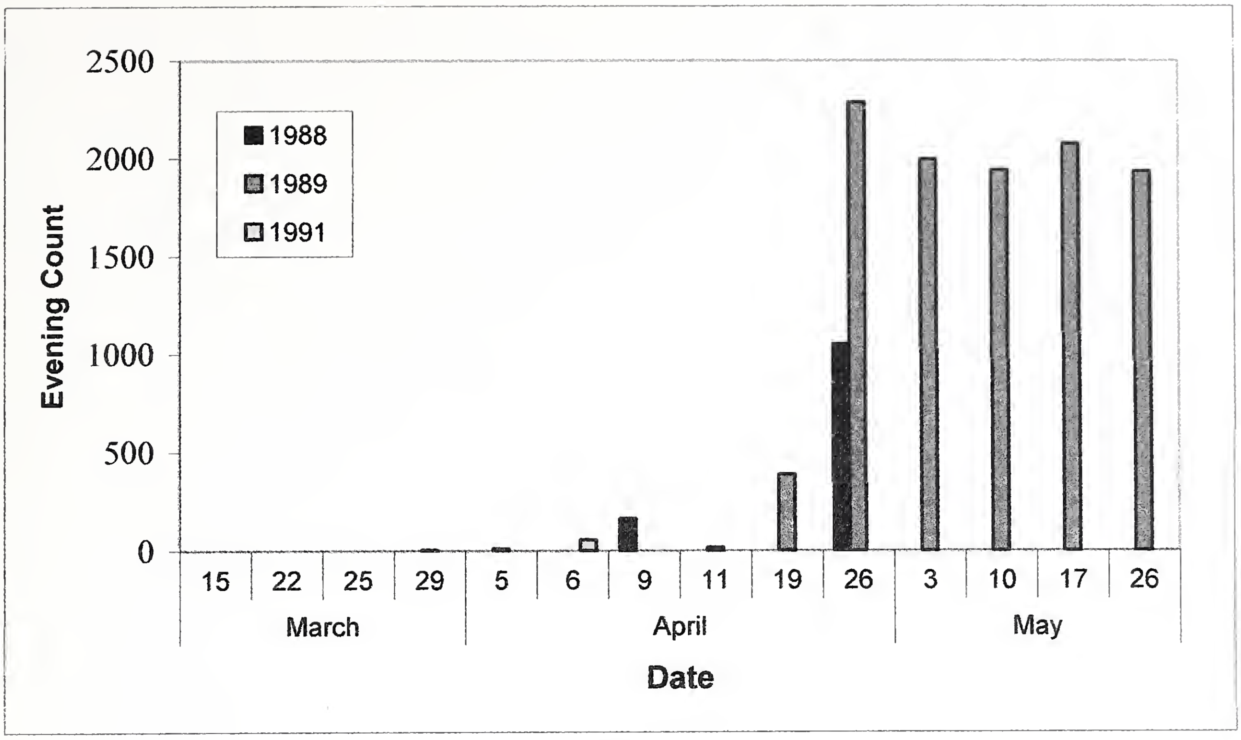

Figure 2.—Spring bat counts in 1988, 1989 and 1991 showing a rapid increase in late April and the buildup complete by May.

were made in 1989 when numbers declined from 2072 in late May to a low of 627 by late June. The first young were seen on 4 June and the first volant young were seen on 15 June 1989. Numbers increased to 1095 bats by 26 July and remained around 1000 bats through August. There were 1254 bats counted on 30 July 1991.

Fall decline.—Fall counts were made in 1988, 1989 and 1990 (Fig. 4). Numbers fell markedly from September through early October though there were many more bats pres-

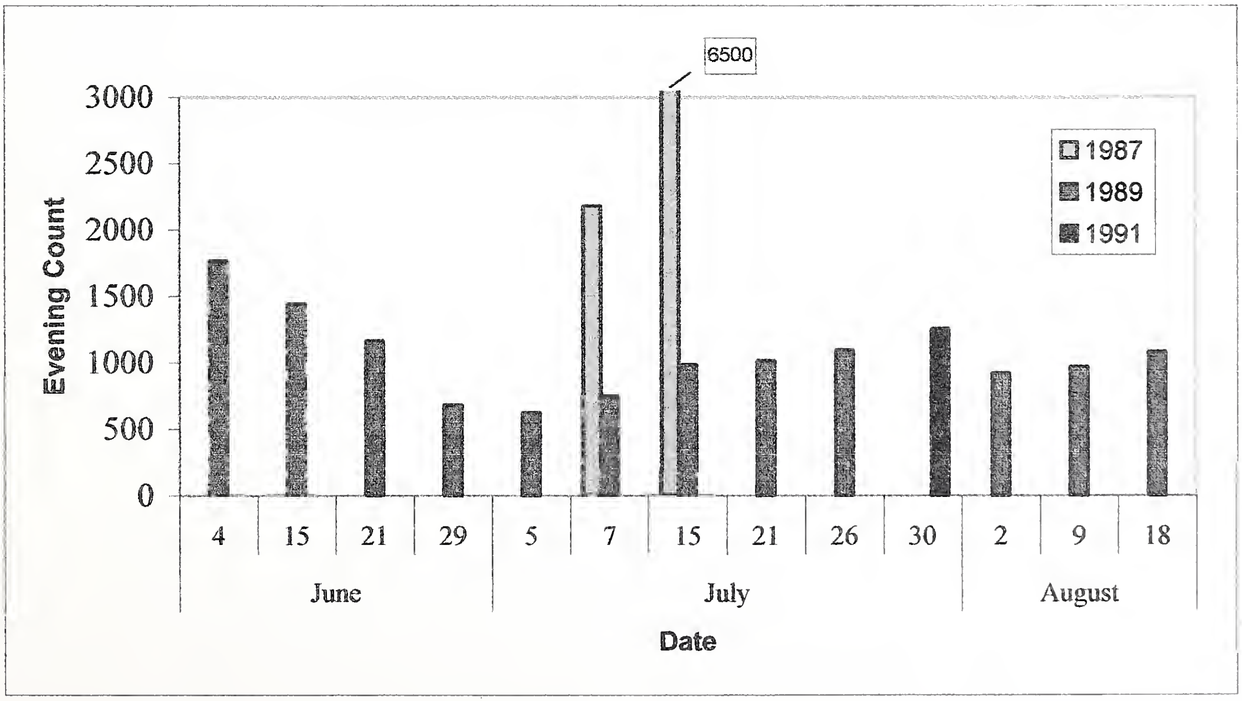

Figure 3.—Summer bat counts in 1987, 1989 and 1991. A large increase was seen in 1987, with a dramatic decline through June 1989. The 1991 count was most similar to numbers in 1989.

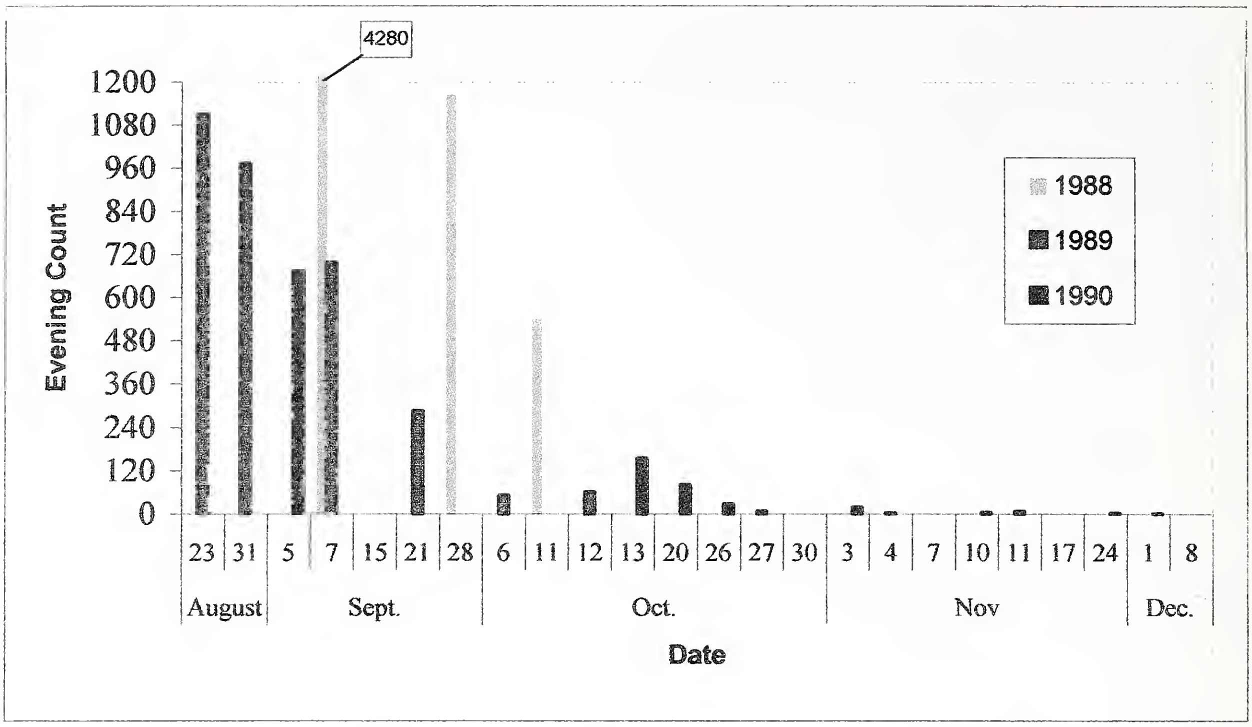

Figure 4.—Fall bat counts in 1988, 1989 and 1990 indicate rapid declines through September and early October but with many more bats present in 1988. Most bats were gone by early November each year.

ent in 1988. In 1988, there were 4381 bats on 7 September and 540 on 11 October. In 1989 and 1990, there were fewer than 700 bats in early September and around 100 remaining in early October. Very few bats remained by early November and only one bat was seen on 1 December 1990. No bats were seen either in the barn or exiting on 8 December 1990.

Banding returns.—Between 1988 and 1992, 26 banded bats were found at six locations in central and southern Indiana and Kentucky (Fig. 1, Table 1). Seven bats total were found in the summer and the other 19 were found in winter. In 1988, a dead juvenile bat was found in a warehouse in Terre Haute, Indiana approximately 24 km west of the barn. In 1992, six banded bats were counted in a nearby church colony at Prairie City, Indiana on 30 July. Banded bats from the barn had been commonly seen in the church prior to 1992; and while no specific counts were made, an estimated 5–10 bats were seen per visit.

Table 1.—Relocated bats from the Brazil colony. Most were hibernating bats found at Ray's cave between October and April. Winter locations showed a wide range of distances while summer locations were relatively close to the barn.

Date	Location	Bats	Distance (km)
8 August 1988	Terre Haute	1	24
11 October 1988	Ray's Cave	1	60
13 January 1989	Colossal Cave	1	280
27 January 1989	Ray's Cave	11	60
27 January 1989	Tunnel Cave	2	150
12 April 1989	Ray's Cave	2	60
13 January 1990	Ray's Cave	1	60
6 March 1990	King Blair Cave	1	48
30 July 1992	Prairie City	6	3

The remaining bats were found hibernating in caves between October and early April. Fifteen were found in Ray's Cave, approximately 60 km south and one at King Blair Cave, approximately 48 km southeast of the barn. Two bats were found at Tunnel Cave, approximately 160 km southeast of the barn and one bat was found approximately 280 km south at Colossal Cave in Kentucky.

DISCUSSION

Spring buildup.—The trend of rapid spring buildup is similar to that observed in central Indiana by Humphrey & Cope (1976) who observed spring buildup beginning in early April and complete by early May. The pattern is also similar to spring emergence of little brown myotis from an abandoned mine hibernaculum at Copperhead Cave in Parke County, Indiana (approximately 30 km northwest of the barn) where bats leaving hibernation emerged from March to May (Whitaker & Rissler 1992).

Summer patterns.—The increase in July 1987 was similar to the pattern expected by the addition of volant young; however, no data on the onset of volancy were collected that year. Summer counts in 1989 show a much different pattern than that seen in other studies. Humphrey & Cope (1976) noted a decline following spring buildup and continuing until late June when young become volant and numbers increased. They attributed this decline to the movement of transient individuals into and out of the population during spring buildup. While the 1989 decline at Brazil began after spring buildup, it was unusual because it continued after parturition and volancy of young when the population should have been the largest. Apparently the peak expected from the addition of volant young was masked by the declines. The population did not begin to increase until early July, well after young were flying. It is possible that the young seen during June were born early and that the majority of young were born in July thus accounting for the increase. However, visual inspections in the barn were made after each count in 1989, and non-volant young were only seen in early June. It is also possible that there were fluctuations in the population that weekly counts did not detect. Using daily flight counts, Humphrey & Cope (1976) reported an increase from 570 to 1360 bats in one colony in late July. They noted that the peak of 1360 was brief and would have been missed by using weekly counts alone. Though they attributed some of these peaks to females not joining in early evening flights, the marked daily fluctuation in numbers suggests the use of alternative roosts. The large increase in July 1987 may have been due to the onset of volancy. However, even 100% reproduction could not have accounted for the increase, suggesting the use of alternative roosts by large numbers of individuals.

Other factors that might affect population numbers include high adult mortality, low reproductive success, inclement weather, researcher error, and human disturbance. No evidence was found to suggest high mortality (i.e., large numbers of dead bats in the barn) and while low reproductive success would have influenced any peak associated with the addition of volant young, it would not explain the severe drop prior to parturition. Syme et al. (2001) noted significant differences in the numbers of little brown bats using some roosts between years at Chautauqua, New York. They attributed this to increased clustering by bats in cooler years. At Brazil, 1989 was not a significantly cooler summer and weather did not appear to be a factor in the decline that year.

Given the large number of bats in the barn and difficulty in making dusk counts, some human error undoubtedly occurred; but we are confident it did not account for the large fluctuations observed. Disturbance from capturing and collecting bats can also influence movement patterns (Humphrey & Cope 1976), but this seems unlikely to have accounted for the patterns seen in 1989, since the steepest declines occurred before any captures were made that year. Some repairs were made on the roof of the barn in late July, and bat numbers dropped slightly in early August. While it is difficult to determine the extent to which these small fluctuations were influenced by the captures or roof repairs, disturbance did not seem to be a factor in the large declines in June.

How the destruction of the barn in 1992 might have influenced bat movements is unknown. Neilson & Fenton (1994) reported a small number of banded bats moving between several buildings used as summer roosts in Chautauqua, New York. They found that most banded bats (91.8%) roosted only in the building where initially caught, and that the majority of movement between roosts that did occur was in June. They further noted that bats roosting in buildings that were torn down did not make use of nearby buildings or bat houses, and that very few bats from razed buildings (0.9%) were recaptured at other buildings that year. Whether the banded bats seen in 1992 at the Prairie City church were there as a result of the destruction of the barn is unknown. However, the regular occurrence of banded bats in the church prior to 1992 indicates regular use and prior knowledge of the church colony. This also provides evidence of the use of alternative roosts by bats in the barn colony. It appears that major fluctuations in this study were due to movements of bats between alternative roosts, most of which were not found. Though little brown bats are generally considered sedentary (Humphrey & Cope 1976), some use of alternative roosts has been noted; and we suspect that there is much more movement between roosts by this species than previously thought.

Fall declines.—In 1988, 1989 and 1990, numbers declined by approximately 90% from September through early October, with most bats gone by November. However, there were six times as many bats in early September 1988 as in subsequent years. Whether this indicates that the 1988 population was unusually high or that other years were low is difficult to determine. Like the summer decline in 1989, we suspect that the use of alternative roosts was a factor in the marked difference between 1988 and other years. To what extent the differences reflect the larger declines described by Cope et al. (1991) is also unknown since no long-term data were collected on this colony.

Banding returns.—Relocation data, though limited, indicate some use of alternative roosts and that at least some bats travel long distances to hibernate. The difficulty in locating both summer and winter roosts makes extensive data difficult to collect. However, given the long term declines in Indiana, these types of data will be important in understanding movement patterns of this species.

ACKNOWLEDGMENTS

We would like to acknowledge Cindy Wright (deceased) who helped extensively with evening flight counts in 1989 and 1990.

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MINUTES OF THE MEETINGS OF THE INDIANA ACADEMY OF SCIENCE 2000

EXECUTIVE COMMITTEE

Indiana University East, Richmond
14 April 2000

President Ruth Howes called the meeting to order at 1:05 PM in Room 200C of the Whitewater Building. Members present: Robert Dale, Edward Frazier, Ruth Howes, Marion Jackson, Duvall Jones, Nelson Shaffer, and Robert Waltz.

The minutes of the Executive Committee meeting on 4 November 1999 held at the University of Southern Indiana were approved. The tentative agenda for this meeting were approved. Frazier moved that funds for the IAS Newsletter be budgeted under those for the Publications Committee. Passed unanimously. No known progress on finding a new IAS *Proceedings* Editor.

Howes had previously mailed to the Executive Committee and other participants in the IAS Planning Retreat the final summary of that retreat (held 18–19 February 2000 at St. Mary-of-the-Wood College), in which responses to several earlier e-mail versions were considered. She also distributed three "Action Items for the Executive Committee from the Planning Retreat," action on the first (#1) of which was handled above by Frazier's motion. Item #2 was that the Executive Committee recommend that the Council direct the Academy Foundation Committee to move assets within the Wright Fund to meet the needs of the research budget presented in the Report of the Planning Retreat. This item was agreed to unanimously.

In lieu of item #3, Frazier moved that the Executive Committee recommend to the IAS Council and the membership that not more than $15,000 per year for a period not to exceed five years be transferred from the Foundation Invested Income Account to the Academy Operating Fund. Passed unanimously.

Since Frank Guthrie, Chair, Academy Foundation Trustees, could not attend this meeting, Shaffer entered for the record Guthrie's e-mail personal comments of 12 April 2000 indicating that the five goals presented from the IAS Planning Retreat are "overly optimistic and often very unrealistic." Guthrie also indicated that the Academy Foundation Trustees did not support item #3, which led to Frazier's above motion.

New Business: Howes appointed Marianna J. Zamlauski-Tucker to the Research Grants Committee for one year in lieu of Anne Spacie. Shaffer reported that Robert Howe will serve on this committee this year but not next year. Howes appointed Tracy Branam to succeed Howe.

Shaffer reported that 39 state agencies have come together to coordinate GIS studies, funded through the state agencies. He recommended that President Howes write an IAS commendatory letter to the Chair on this much-needed effort. There is another GIS meeting on 20 April 2000, and Howes appointed Ed Squiers and Robert Waltz to represent IAS at this meeting.

Another item of discussion from the IAS Planning Retreat was to change Article VI, Section 3 of the IAS Constitution on the constituency of the Executive Committee to delete the Editor of the *Proceedings* and to add the Chairs of the Academy Foundation Committee and the Research Grants Committee. After a brief discussion Frazier moved that the first sentence in Article VI, Section 3 be changed to read, "The Executive Committee of The Academy shall consist of the current elected officers, the immediate past president, and the chairs of the Academy Foundation Committee and Research Grants Committee." Passed unanimously. (Note that the Constitution may be amended at any annual meeting of The Academy by an affirmative vote of three-fourths of the members in attendance and voting, provided that the amendment has been submitted to the membership at the previous regular meeting, or by mail, at least 30 days prior to the date on which the amendment is presented for adoption and that it has been approved by the Council.)

Frazier distributed and reviewed the IAS Account Summary from 1 January to 15 April 2000, as well as the account for the 1999 Fall meeting and those for each of the previous Fall meetings back to 1991. He pointed out that the expenses for the 1999 Fall meeting were $1,462 over the income, which is about average except when the meetings are held at Purdue or Indiana Universities, when the loss is closer to $10,000. Squiers moved that Frazier be commended for an understandable budget presentation. Passed unanimously.

Dale congratulated President Howes for her excellent summary of the IAS Planning Retreat 18–19 February 2000.

Howes terminated the meeting at 2:00 PM.

COUNCIL MEETING

Indiana University East, Richmond
14 April 2000

President Ruth Howes opened the meeting at 2:05 PM by asking Council members for a standing introduction.

Members present in addition to those listed for the Executive Committee meeting: James Berry, Stan Burden, Dick Conklin, David Daniell, Kris Dhawale, William Gommel, Nils Johansen, Richard Kjonaas, George Mourad, Holly Oster, Donald Ruch, Damian Schmelz, Ed Squiers, Dan Webster and Terry West.

Webster moved that the minutes of the Council meeting held 4 November 1999 at the University of Southern Indiana be approved as duplicated and mailed. Passed unanimously.

Agenda for this meeting were approved.

Frazier distributed his IAS Account Summary 1 January–15 April 2000, the IAS 1999 Year End Financial Report, and the Financial Report on the 1999 Fall Meeting at the University of Southern Indiana, reviewing them briefly.

Waltz, Chair of the Audit Committee, reported that the financial records of IAS were examined on 31 March 2000 and appear to be fair and accurate.

Shaffer reported that Gary Dolph could not be here, and distributed his report. Dolph has authorized printing of Vol. 106 (3–4) of the *Proceedings*, and it will appear soon. He has 14 articles in various states of review and plans to put them all in Vol. 107 (1–4). Volume 108 (1–4) will be on the Grand Calumet Basin; but because of some difficulties, it has taken eight months of editing time. No information is available on the search for a new *Proceedings* Editor.

President-Elect Squiers proposed three methods of increasing our IAS membership: (1) encourage more graduate student thesis presentations at the Fall meetings rather than at national meetings, (2) encourage state scientific agencies to participate in the Fall meetings, and (3) work on a mobile IAS display for appearances at HASTI and other science and teaching meetings in the state.

Howes presented the items from the Planning Retreat for action by the Council.

Gommel moved to approve the first (I) action item, seconded by Frazier, although there was discussion and minor editing on #1, 4, and 5:

I. The Council of the Indiana Academy of Science sets the following goals for the Academy during the next five years:

(1.) Indiana Academy of Science will be identified as a respected voice of science in Indiana. (2.) The majority of working scientists in Indiana will be members of IAS. (3.) Indiana Academy of Science will actively promote science and science education from kindergarten to graduate school and in informal science-based activities like museums. (4.) Indiana Academy of Science will promote all research in science, but especially that particularly relevant to the State of Indiana. For example, this includes such activities as studying flora and fauna native to the state or studying the state's geology or climate. (5.) Indiana Academy of Science will be recognized as a non-partisan source of advice on issues with scientific content by state agencies, the legislature and the executive branch of state government. The Academy will take positions on issues which clearly impact the health of science in Indiana while avoiding taking issues on political issues.

The motion was approved unanimously.

II. Research grant recipients will be ineligible for further funding if a satisfactory scientific record describing previously funded research is not on file.

III. The Council directs the Research Grants Committee to develop guidelines for highly competitive Wright Grants following the model presented in the report of the Planning Retreat.

Squiers moved to approve action items II and III, seconded by Waltz, and the motion passed.

Since Council action items IV and V were negated by the preceding Executive Committee meeting, Frazier moved that the IAS Council recommend to the membership that not more than $15,000 per year for a period not to exceed five years be transferred from the Foundation Invested Income Account to the Academy Operating Fund. Seconded by Waltz and approved.

Frazier also presented his motion to change IAS Constitution Article VI, Section 3 on the membership of the Executive Committee. (See Executive Committee minutes.) Passed.

Schmelz, IAS member on the 12-person Natural Resources Commission, distributed his report. NRC sets policy for the Department of Natural Resources, the most controversial issue being the disposal of coal combustion wastes in strip mine pits.

Kjonaas distributed his report as the IAS representative to the AAAS. There were only 20 delegates at the National Association of Academies of Science, and most were the Executive Directors of their respective state academies of science. The workshop was "Will Kansas be cloned?" and several key strategies were discussed to ensure acceptance of teaching evolution in the public school science curriculum. The cost of his trip to Washington was greater than that budgeted by IAS, and Gommel moved that the difference in costs be paid to Kjonaas. Passed.

Gommel reported two deaths of IAS members since the annual meeting, Alton Lindsey and Robert Brooker, both obituaries printed in the March 2000 IAS Newsletter. The deaths of two other members were reported at the meeting, Herman Wells, IU, and Elmer Nussbaum, Taylor University. Gommel also reminded all members to send him, Shaffer, or Oster their resumes and any member obituaries they see.

Frazier reported on Frank Guthrie's comments on Howes' report on the Planning Retreat. See Executive Committee minutes.

Mourad thanked Claire Chatot, previous Chair of the Research Grants Committee, for a smooth transition, and reported 23 of 43 research proposals funded. Research proposals are read, rated, and funding amounts suggested by each of all five members; and it is difficult to do this in a few weeks. He recommended that the deadline for receipt of the proposals be moved from 3/15 to 3/1 and from 9/15 to 9/1.

Webster requested nominations for awards ASAP.

Ruch reported IAS funds for the Biological Survey are being used by Ron Hellenthal to load data into the Indiana Biological Survey Biodiversity Data Model, there will be a Biological Survey meeting in May 2000, and a workshop on mushrooms at the Fall meeting. The first printing of the flier on exotic plants and the replacement plants has been exhausted.

Oster reported there are no new initiatives in the 2000 budget preparation year and no new money for the IAS *Proceedings*. She has a growing file of resumes and pictures of IAS members. The Academy archives will stay at the State Library.

Dhawale reported all rooms at IUE reserved for the Fall meeting and anticipates no problem with receiving abstracts in electronic formats.

Conklin asked for nominations for President, Secretary, and Research Grants Committee. Appointments have been made for Howe and Spacie, but we need a replacement for Steven Perrill.

Daniell reported the IAS meetings in 2001 will be at IU-PU Fort Wayne, but as yet we do not have a definite location for 2002.

Jones distributed and reviewed a draft report, "Help for Science Mentors," to stop the decline in IAS Youth Activities and focusing on the need for more science mentors.

Shaffer requested that IAS work with a GIS group running out of IUPUI for coordination, Howes and Shaffer to write a letter of support, and Squiers and Waltz to represent IAS at the next GIS group meeting 4/20/2000.

Berry reported the deadline for the next newsletter is June 1.

Jackson reported the IU Press is reprinting "Natural Heritage of Indiana."

Meeting adjourned at 5:25 PM.

Most IAS Council members and guests then met at the Carver's Family Restaurant for dinner at 5:45 PM. After dinner, Professor Jon Branstrator, Earlham College, lectured on "Oceans, Ice, Agriculture, Industry and Economic Development - Richmond's Environmental History," and then described the three tours planned to begin at 9:00 AM on Saturday morning: #1—Hayes Regional Arboretum on the east side of Richmond; #2—Cope Environmental Center; #3—A 4-mile hike down the Whitewater River Gorge. Jon and Peggy Branstrator, Neil Sabine, and Mary Ann Morse led these interesting tours. People on the Whitewater Gorge tour found many fossils, such as horn corals, 500-million years old. Thanks to our IUE hosts and Earlham volunteers for a wonderful two days.

Respectfully Submitted,
Robert F. Dale, Secretary

EXECUTIVE COMMITTEE

Indiana University East, Richmond
2 November 2000

President Ruth Howes called the meeting to order at 1:15 PM in the Community Room of the Whitewater Building, I.U. East, Richmond, Indiana.

Members present: James Berry, Robert Dale, Gary Dolph, Edward Frazier, Uwe Hansen, Walter Hasenmueller, Ruth Howes, Marion Jackson, Duvall Jones, Bill McKnight, Holly Oster, Edwin Squiers, Nelson Shaffer, and Terry West.

The minutes of our Executive Committee meeting on 4 April 2000 held at I.U. East were approved. The tentative agenda for this meeting were approved.

As the first item of his Publications Committee report, McKnight moved that Jim Berry of Butler University be named Editor, *Proceedings* of the Indiana Academy of Science. Approved unanimously. McKnight also recommended that Gary Dolph be commended for his 10 years service as Editor of the *Proceedings*. Approved unanimously. He then moved that Uwe Hansen be named Editor of the IAS Newsletter, and that Jim Berry be thanked for his current and past service as Editor of the newsletter. Passed unanimously. Dolph delivered a box of current *Proceedings* papers for publication to Berry, but he will finish his editing of Volume 108 on the Grand Calumet Basin.

McKnight reported on four special publications in progress: Amphibians and Reptiles, Sunflowers, Dragonflies, and the reprinting of "Butterflies of Indiana," as well as the possible reprinting or the revised 5th edition of "Plants of the Chicago Region." (Details were included in his 18 August memo to the Publications and Executive Committees with enclosures).

Frazier distributed and reviewed his Treasurer's Account Summary and 1 January–31 October 2000 Budget Comparison report. Approved. He pointed out that *Proceedings* IAS page charges were started this year.

Shaffer distributed his report on the IAS membership for each of the last five years, ending with

2000, showing the disturbing downward trend in the total membership as well as in most of the membership categories. With the loss of PSI to CINERGY, we are left with only one Corporate member, Lilly. The need for more members in all categories was discussed. On the other hand, Howes pointed out that the Junior Academy membership has increased due to the efforts of Duvall Jones, Linda Airey, and Shireen DeSouza.

Berry distributed and reviewed his report on possible changes (9) in the *Proceedings* of the IAS, inviting members to attend the discussion session on the future of the *Proceedings* at 2:30 PM, 3 November in Room 222, Whitewater Building.

Hansen discussed his plans and possible items for the IAS Newsletter.

Squiers listed his first five efforts as President-Elect: (1) Obtain IAS stationery for Shaffer and Secretary, (2) Work to pass state legislation to change the State Wild Flower from the peony to the fire pink, (3) Get a movable display booth to advertise the IAS, (4) Pursue increasing the number of corporate IAS memberships (@ $500), to 20 this year, as well as members, and (5) Schedule IAS budget meeting at Taylor University for 2 December 2000.

Howes will ask members to approve two items at the annual meeting tomorrow: (1) the change to the constitution in the membership of the IAS Executive Committee, and (2) the movement of not more than $15,000/year for a period not to exceed five years from the Foundation Investment Income Account to the Academy Operating Fund beginning in the year 2001. (These items were approved by the Council at the Spring 2000 meeting, but have to be voted on by the entire membership at the annual meeting). She also distributed and reviewed a plan for involving Indiana high school students in research. This moves the talent search from Spring to Fall and seeks more cooperation with the Hoosier Association of Science Teachers Inc. (HASTI) and the Science Education Foundation of Indiana (SEFI) by having a joint steering committee of two members each from IAS, HASTI, and SEFI. The IAS members will be the Director of the Junior Academy and the Chair of the Science Talent Search Committee. Squiers moved approval, second by Jackson, and passed unanimously.

Frazier distributed Frank Guthrie's Academy Foundation Trustee Report, pointing out that the transfer of assets in the John Wright Fund, the Investment Income Account and the Academy Foundation to Merrill Lynch from Bank One appears to be accomplishing the goals of the Trustees. The Trustees are making good progress toward the five-year goal of increasing funds for research grants and other authorized projects.

Under new business, Howes reported that AAAS has asked IAS to appoint a representative to the AAAS Section Committee on General Interest in Science and Engineering (Y). Shaffer moved that Kjonaas be so named, Squiers seconded and passed unanimously.

Howes adjourned the meeting at 3:00 P.M.

COUNCIL MEETING

Indiana University East, Richmond

2 November 2000

President Ruth Howes opened the meeting at 3:10 PM in the Community Room of the Whitewater Building by asking Council members for a standing introduction. Members present in addition to those listed for the Executive Committee meeting: Dick Conklin, Shree Dhawale, Rebecca Dolan, William Gommel, Jim Haddock, Ronald Hellenthal, Nils Johansen, Richard Kjonaas, Marcia Moore, George Mourad, Roger Ratcliffe, Donald Ruch, Damian Schmelz, John Schutt, Walter Wager, and Dan Webster.

Hearing no objections, the minutes of the 14 April 2000 meeting were approved. After adding the IAS website, the agenda were approved.

Frazier distributed and reviewed his Treasurer's Report.

Shaffer distributed and discussed his IAS Membership Report as of 1 November 2000 (see Executive Committee minutes).

Dolph distributed the contents page for Vol. 107, 1–4 (1998), less page numbers, and indicated that the manuscripts for works in progress had been given to Jim Berry, the new Editor for the *Proceedings*, with the exception of those for the Grand Calumet Basin, which he will finish in Vol. 108 (1999). Berry distributed his suggestions for changes in the *Proceedings* and invited all to the discussion tomorrow afternoon.

Howes asked everyone to help bring a "For" vote on the two items to come before the annual meeting tomorrow (See Executive Committee Minutes).

Squiers, to increase the IAS visibility in the State, indicated the five goals he will try to accomplish in 2001 (see Executive Committee minutes), as well as exploring the use of the Past President's fund.

With regard to changing the state flower, Ruch said the Indiana Native Plant and Wildflower Society (INPAWS) has prepared a two-color flier on this. Squiers moved that IAS support the state flower bill, changing the peony to the native fire pink. Approved unanimously.

Schmelz distributed and discussed his Report on the Natural Resources Commission, which meets monthly and sets policy for the Dept. of Natural Resources.

Kjonaas distributed and discussed his report as IAS Representative to the AAAS. At the 2000 NAAS meeting 17 of the 44 state academies were represented at the Assembly of Delegates, and student presenters at the AJAS represented 27 state academies. Twelve states fail so thoroughly to teach evolution as to render their standards totally useless.

Nelson moved that Kjonaas also represent IAS on the AAAS (Y) committee (see Executive Committee minutes). Seconded by Gommel and approved.

Gommel read names of members reported deceased and asked for any others known to the Council, as well as vitae from all members.

Oster distributed her annual report 2000 for the IAS Wright Memorial Library. The *Proceedings* of the IAS, Vol. 106, No. 3–4 was mailed to 636 eligible IAS members, 69 Indiana libraries, and 16 indexing/abstracting services. She constructed an exhibit showing the historical relationship between the Indiana State Library and the IAS for the 175th anniversary of the State Library and the inauguration of the renovation of the Library and Historical Building on 6 October. Several updates were made to the Indiana State Library/IAS webpage, including a link to the "IAS.org" site. She will take down her website when the new website at Butler is ready. Oster also distributed a letter from the Gale Group, Farmington Hills, Michigan, 7 July 2000, with attachments of Gale Group Databases and Licensing Agreement, asking to license *Proceedings* of the IAS. They will pay royalties to IAS and start with 1999. After discussion, Gommel moved that we sign an agreement for a three-year period, pending further investigation by Shaffer, Frazier, and Oster. Seconded by Frazier and passed unanimously.

Howes thanked Shree Dhawale for all the work and excellent facilities he and his committee had arranged at IUE for our Spring and Fall IAS meetings.

Haddock distributed and discussed his report on plans of the Local Arrangements Committee for the 20–21 April 2001 and 8–9 November 2001 meetings at the Indiana University-Purdue University Fort Wayne campus.

Moore and Dolan distributed IAS website pages available on http://www.indianaacademyofscience.org being constructed at Butler University. This IAS website is being provided and kept up-to-date by Butler as a service to the citizens of Indiana with no cost to IAS. Any questions should be addressed to Marcia Moore at mmoore@butler.edu, or (317)-940-8302.

Webster distributed the Awards Committee recommendations:

Emeritus membership—Howard E. Dunn, Chemistry, University of Southern Indiana; Fellow—William R. Adams, Anthropology, Indiana University, Bloomington; Special Service Award—Gary E. Dolph, Editor, *Proceedings* of the IAS.

Award recommendations approved unanimously.

Ruch reported for the Biodiversity and Natural Areas Committee. Tom Simon is Chairman of the Indiana Biological Survey, which is patterned after the program in Ohio. Their website, indianabiologicalsurvey.org is almost ready. The BNA committee (Ruch) will host "How to Identify Mushrooms—The Basics for the Beginner" at 1:00 P.M. on 3 November in 221 Whitewater Building, and he apologized for scheduling this special session at the same time as the annual IAS meeting.

Hellenthal briefly described his work on databases and information modeling.

Conklin announced the IAS election results: President-Elect—Terry West; Secretary—Nils Johansen; Academy Foundation—Wendell McBurney; and Research Grants—John Huffman.

McKnight reviewed the publications report (see Executive Committee minutes).

Jackson reported that the "Natural Heritage of Indiana" has been reprinted.

Mourad distributed and reviewed the 2000 Annual Report 2000 of the Research Grants Committee. This included tables of both Senior (48) and Junior (27) Research applications for the Spring and Fall 2000, by discipline and university, or high school, and those funded. Due largely to the IAS 18-19 February 2000 retreat, the research funds allocated will increase from $40,000 to $70,000 for senior grants over the next five years and from $2,500 to $3,500 for junior grants. West pointed out disparity between 34 biology proposals funded against 3 for Geology.

Jones thanked Mourad for their overlapping Junior Academy research efforts and distributed a proposal to AAAS for funds ($1,500 for 2000–2001) to support secondary school student research grants, attaching the summary report for the results of the 1999–2000 AAAS $1,500 Grant.

President Howes adjourned the meeting at 5:30 P.M.

GENERAL BUSINESS MEETING

Indiana University East, Richmond
3 November 2000

The annual IAS meeting was opened at 12:50 P.M. with a welcoming statement by Walter Wagor, Asst. Vice-Chancellor for Academic Affairs, IUE. John Schutt introduced the Speaker of the Year, Gary M. Hieftje, Dept. of Chemistry, IU Bloomington, who gave an exciting speech on "Instrumentation Science in the New Millennium."

Ruth Howes called the Annual IAS Business Meeting to order at 1:30 P.M. The first order of business was to approve the two items previously approved by the Council at its 14 April 2000 meeting: (1.) Amending the IAS Constitution to change the membership of the Executive Committee by removing the Editor of the *Proceedings* of the IAS and adding the Chairs of the Research Grants Committee and the Foundation Committee to the Executive Committee, and (2.) Transferring no more than $15,000/year for a period not to exceed five years from the Foundation Invested Income Account to the Academy Operating Fund, beginning in the year 2001. Hansen moved approval of (1), seconded by Squiers, and passed unanimously. Frazier moved approval of (2), seconded by Dale, and passed unanimously.

Squiers moved that IAS support efforts to the change of the state flower from the peony to the native fire pink (*Silene virginica* L.). Frazier seconded and it passed unanimously.

Howes read a Resolution drafted for the IAS meetings 2–November 2000:

Whereas; the members of the Indiana Academy of Science are deeply grateful for the invitation to hold the 116th annual meeting of the Academy on the campus of Indiana University East, at Richmond; and

Whereas; the administration, faculty, staff and students of Indiana University East have cooperated admirably in providing their facilities, resources, and support for this 116th annual meeting of the Indiana Academy of Science; be it

Resolved; that the Academy members here assembled express their sincere appreciation to Dr. David Fulton, Chancellor, and to Vice-Chancellors Diane Roberts, Joanne Matika, and Benjamin Young, for all the courtesies that have been extended to the Academy during this meeting. We are especially grateful to Dr. Shrikrishna Dhawale and Dr. Michael Foos, chairpersons of the local planning committee, to all the members of the committee, and to other facilitators for the arrangements of the entire program and for the comfort and conveniences provided Academy members and guests. We also express our sincere thanks to all Academy members who organized and participated in activities associated with this 116th annual meeting of the Indiana Academy of Science.

Frazier moved approval of the Resolution, seconded by Gommel, and passed unanimously.

Webster announced the awards recipients: Emeritus membership—Howard E. Dunn, Chemistry, University of Southern Indiana; Fellow—William R. Adams, Anthropology, Indiana University, Bloomington; Special Service Award—Gary E. Dolph, Editor, *Proceedings*.

Conklin announced the IAS election results: President-Elect—Terry West; Secretary—Nils Johansen; Academy Foundation—Wendell McBurney; and Research Grants—John Huffman.

Gommel read the names of the following members whose deaths had been reported since our 1999 annual meeting: Robert M. Brooker, William R. Clark, Keith Hunnings, Alton A. Lindsey, Mrs. George F. Martin, Frank J. Welcher, and Herman B. Wells. Members then stood for a moment of silence to honor these departed colleagues for their contribution to the IAS and scientific community at large. Gommel also asked members to send their own vita and obituaries for any members known to have died to him, Oster, or Hansen (new IAS newsletter editor).

Howes announced formation of new website http://www.indianaacademyofscience.org being constructed at Butler University. This IAS website is being provided and kept up-to-date by Butler as a service to the citizens of Indiana with no cost to IAS. Any questions should be addressed to Marcia Moore at mmoore@butler.edu (317)-940-8302.

Howes then thanked all officers, especially Rebecca Dolan, Marion Jackson, and Edwin Squires, for their wonderful help in her year 2000 presidency, and handed the gavel to Squiers.

Squiers thanked Howes for all her efforts in leading the IAS this past year and gave five assignments to the membership: (1). Support the change of the state flower from the peony to the fire pink. (2). Help encourage the use of the moving IAS display by sending information on meetings where the display could be used to make the IAS more visible. (3). Suggest corporations and contacts in same for corporate IAS memberships, to increase these from 1 to about 20 in 2001. (4). Recommend your associates for IAS membership. (5). Visit our new website or the old one at the State Library and click on the new one.

Squiers adjourned the 116th IAS annual meeting at 2:00 P.M.

Respectfully submitted,
Robert F. Dale, Secretary IAS

2002. Proceedings of the Indiana Academy of Science 111(2):227–231

MINUTES OF THE MEETINGS OF THE INDIANA ACADEMY OF SCIENCE 2001

EXECUTIVE COMMITTEE

Indiana University-Purdue University
Fort Wayne
20 April 2001

President Ed Squiers called the meeting to order at 1:10 PM. Attending: President-Elect Terry West, Treasurer Ed Frazier, Secretary Nils I. Johansen, Past-President Ruth Howes, George Mourad, Jim Berry, Frank A. Guthrie, Uwe Hansen, Executive Director Nelson Shaffer.

Minutes from the meeting of 2 November 2000 at I.U. East, Richmond, were approved with typos corrected as shown.

Tentative agenda were approved.

Treasurer's Report: Dues are slower coming in for renewals. The number of corporate sponsors is down. Presented Finance Committee report from its 14 April meeting. (Approval pending Council meeting). Presented 2000 year end financial report (Approval pending Council meeting).

Executive Director's Report: Dues are late coming in. Shaffer will send out reminders. There are 722 paid, and 60 late as of 19 April 2001. The number of Corporate sponsors is down, and Shaffer will investigate. Yearbook is late (pending late dues). Will be coming out shortly. Shaffer has an IAS talk prepared with visual aids for presenting to groups.

Six members passed away since last meeting.

Discussion followed on membership in general, especially suggestions on how to increase membership.

Academy Foundation Report: Guthrie distributed a written report. He noted that the value of the portfolio is down to $6.6 million from $7.3 million, a reduction of 9%, very good considering the recent stock market fluctuations. The fund is well hedged against the market. A change in fund management to Merrill-Lynch resulted in a $15,000 savings in management fees and $49,000 increased income. The committee is pleased with Merrill-Lynch as the fund manager. The Invested Income Account has $36,000 as of 31 March 2001. This combined with investment income of estimated $20,000 and a 31 October-maturing Treasury note ($50,000) should be sufficient to support the Fall round of research grants and the first appropriation to the operating budget. The Academy Foundation Account has about $23,000 in cash and investment should yield about $13,000 annually. This is ample to support currently funded programs.

Secretary's Report: Minutes of past meetings were distributed at the beginning of today's meeting. Corrections noted.

President-Elect's Report: West stressed the importance of good communications within the organization, and the need to verify e-mail addresses.

President's Report: Squiers reported that the good news for IAS is that we have good people making things happen in the various committees. He complimented the members for the work they do. We have a display that is used, but the organization struggles with relevance. The President's charge is that we need to be relevant. We need to empower the section chairs. Suggestions were discussed on how to combine the input from the section chairs for the presentations at the Fall meeting with the electronic submission of abstracts directly to the Local Arrangements Committee. Further discussions with the Executive Director will continue to clarify this.

There was also discussion on how to recognize student presentations at the section presentations. Squiers also reported on his first five efforts: (1) Obtain stationery for Secretary and Executive Director: Done; (2) Change the state flower to firepink: Frustrating, no legislative action expected at this time, although there seems to be no opposition to the idea either. He will continue to work on this; (3) Movable display booth: Done; (4) Increase corporate members: Frustrating, membership down. Will work with Executive Director to explore possibilities; (5) Budget meeting December 2000: Done.

Publications: Report postponed until the Council meeting immediately following this meeting.

Proceedings: Berry reported that since the *Proceedings* is so far behind (2 years), he wants to jump ahead. He will coordinate with Oster to make this transition. There will be changes in the page charges, but no firm decision at this time. We need three editorial board members; anthropology, mathematics and psychology. Suggestions to be forwarded to Berry.

Newsletter: Hansen reported on the status of the Newsletter. Suggestions for continued improvement included having the due date for contributions to the next issue be included in every issue. The Newsletter is the public face of the Academy. Make it "splashy."

Grants: Mourad passed out the report of the Research Grants Committee. He emphasized that grant applicants need to be aware of the guidelines, i.e., "read the web-site."

Old Business: Shaffer asked for a vote on the acceptance of the Gale Group license as discussed last meeting. Moved by Howes, seconded by Mourad to accept. Passed unanimously.

New business: None.

Meeting adjourned 3:07 PM.

Respectfully submitted,
Nils I. Johansen, P.E.
Secretary, IAS

COUNCIL MEETING

Indiana University-Purdue University Fort Wayne

20 April 2001

President Ed Squiers called the meeting to order at 3:24 P.M. Attending: Executive Committee and Council members: President-Elect Terry West, Treasurer Ed Frazier, Secretary Nils I. Johansen, Past-President Ruth Howes, George Mourad, Jim Berry, Frank A. Guthrie, Uwe Hansen, Executive Director Nelson Shaffer; Council members: Jim Haddock, Duvall A. Jones, Richard Kjonaas, Dan Webster, Donald Ruch, David Daniell, Damian Schmelz, Bill McKnight, and Holly Oster.

Minutes from the meeting of 2 November 2000 at Indiana University East, approved with typos corrected as shown.

Tentative agenda approved.

Treasurer's Report: Dues are slower coming in for renewals. The number of corporate sponsors is down. Presented and distributed the Finance Committee report from its 14 April Meeting and the 2000 year end financial report. Motion by Frazier, Schmelz seconded, to approve the reports. Passed unanimously.

Executive Director's Report: Dues are late coming in. Shaffer will send out reminders. 722 paid, 60 late as of 19 April 2001. Corporate sponsors are down, Shaffer will investigate. Yearbook is late (pending late dues). Will be coming out shortly. Shaffer has an IAS talk prepared with visual aids for presenting to groups.

Six members passed away since last meeting. Discussion followed on membership in general, especially suggestions on how to increase membership.

Asked for a motion to accept the Gale Group's proposal to list the *Proceedings* on line. West made motion, Webster seconded to approve. Passed unanimously.

Academy Foundation Report: Guthrie distributed a written report. He noted that the value of the portfolio is down to $6.6 million from $7.3 million, a reduction of 9%; very good considering the recent stock market fluctuations. The fund is well hedged against the market. A change in fund management to Merrill-Lynch resulted in a $15,000 savings in management fees and $49,000 increased income. The committee is pleased with Merrill-Lynch as the fund manager. The Invested Income account has $36,000 as of 31 March 2001. This combined with investment income of estimated $20,000 and a 31 October maturing Treasury note ($50,000) should be sufficient to support the Fall round of research grants and the first appropriation to the operating budget. The Academy Foundation Account has about $23,000 in cash and investment should yield about $13,000 annually. This is ample to support currently funded programs.

Secretary's Report: Minutes of past meetings were distributed at the beginning of today's meeting. Corrections noted.

Publications Committee Report: McKnight reported the status on the following publications: "Dragonflies"—final draft off next week; "Sunflowers"—scheduled for early May, four weeks for galley proofs, out by July? "Amphibians and Reptiles"—almost ready for galleys. The publications web-site is in the works.

Newsletter: Hansen reported on the status of the Newsletter. He is working on improving the images and general layout. Suggestions for continued improvement included having the due date for contributions to the next issue be included in every issue. The Newsletter is the public face of the Academy. Make it "splashy."

Proceedings: Berry reported that since the *Proceedings* is so far behind (2 years), he wants to jump ahead. He will coordinate with Oster to make this transition. There will be changes in the page charges, but no firm decision at this time. We need three editorial board members; anthropology, mathematics and psychology. Suggestions to be forwarded to Berry. Berry will continue to work on timeliness and pick up abstracting services.

President-Elect's Report: West stressed the importance of good communications within the organization, and the need to verify e-mail addresses. West stated that this year as president-elect it would be his "learning year."

President's Report: Squiers reported that the good news for IAS is that we have good people making things happen in the various committees. He complimented the members for the work they do. We have a display that is used, but the organization struggles with relevance. The President's charge is that we need to be relevant. We need to empower the section chairs. Suggestions were discussed on how to combine the input from the section chairs for the presentations at the Fall meeting with the electronic submission of abstracts directly to the Local Arrangements Committee with a copy to the section chair. Further discussions with the Executive Director will continue to clarify this.

There was also discussion on how to recognize student presentations at the section presentations. Squiers also reported on his first five efforts: (1) Obtain stationery for Secretary and Executive Director: Done; (2) Change the state flower to firepink: Frustrating, no legislative action expected at this time, although there seems to be no opposition to the idea either. He will continue to work on this. (3) Movable display booth: Done. (4) Increase corporate members: Frustrating, membership down. Will work with Executive Director to explore possibilities. (5) Budget meeting December 2000: Done. Squiers re-emphasized that IAS needs to move into the 21stcentury.

Indiana Natural Resources Commission: Schmelz distributed his written report. He suggested use of the IAS newsletter to keep members informed about the commission's work.

AAAS Representative: Kjonaas distributed his written report.

Historian's Report: No report.

Committee Reports:

1. Biological Survey: Winona Welch Award report distributed. Indiana Biological Survey Annual Report distributed. Search for corporate sponsors will be coordinated with the Executive Director. The Biological Survey is working on a logo, and will involve high schools in this project.
2. Youth Activities: Jones submitted and distributed his written report. Jones re-emphasized that the youth is the source of our future scientists.
3. Grants: Mourad distributed his committee report. He emphasized that grant applicants need to be aware of the guidelines, i.e., "read the website."

New Business: Daniell announced future meeting hosts: 2002—Butler University; 2003—Anderson University; 2004—possibly Hanover College. Motion by West, Howes seconded, that IAS accept the sites. Passed unanimously. There was some discussion on the date for Fall meetings, Possible coordination with a Fall break would make it more attractive for smaller institutions to host meetings.

Local arrangements: Haddock summarized the field trips for Saturday—18 participants for Geology, 8 participants for Biology and commented on the arrangements for dinner and the evening talk. President Squiers thanked Haddock for the hospitality shown by IPFW for the meeting arrangements and field trips.

Meeting adjourned 5:56 PM.

Respectfully submitted,
Nils I. Johansen, P.E.
Secretary, IAS

EXECUTIVE COMMITTEE

Indiana University-Purdue University
Fort Wayne
8 November 2001

President Edwin Squiers called the meeting to order at 1:08 PM. Attending: Treasurer Edward Frazier, Secretary Nils I. Johansen, Past-President Ruth Howes, George Mourad, Jim Berry, Frank A. Guthrie, Bob Waltz, Executive Director Nelson Shaffer. Also attending: Duvall A. Jones, Jim Curry, Bill McKnight.

Agenda approved by consensus.

Minutes from meeting 20 April 2001 at Indiana University-Purdue University Fort Wayne approved. Motion by Mourad, Howes seconded, unanimous approval.

Treasurer's Report: Frazier passed out financial reports. In summary, no major problems. Frazier appreciated the support of the Academy Foundation. The report "stands approved." There are 179 members pre-registered for the 2001 Fall meeting.

Executive Director's Report: Nelson commented on several issues: Need for more corporate sponsors; continue to work on the "profile" of IAS; signed off on the permission to reprint Academy publications; commented on the IAS display that has been across the State. He also encouraged members to use the display and also to recruit more members. A few comments were raised on the accuracy of the 2001 yearbook. Nelson will bring it up to date, and reminded members to bring errors and/or omissions to his attention.

President's Report: Squiers made several comments: Name recognition for the Indiana Academy of Science. There is apparently some confusion in peoples mind between the Indiana Academy, a high school program, and IAS. Suggested work on search engines in order to hit the IAS when the full name is entered. He commented on the impressive Junior Academy talent search program. Membership is an ongoing project. The wildflower bill is in limbo, but he will continue to bring it to the attention of the appropriate legislators. Challenges still facing the IAS: Increase membership from the pool of professional scientists (researchers) in the State. Need to recruit and groom younger members for leadership roles.

Continue to work on budget issues. Where to go from here? Stay on course. Get other members involved. Help the new President-Elect. We are a financially stable organization, thanks to the Academy Foundation and the diligent work carried out by Guthrie and the cooperative work between the Treasurer and the Trustees of the Academy Foundation.

Comments from others: Howes: A reminder that the President grooms the President-Elect. Nelson: Raised the question about an intern. How about having a high school, undergraduate, or graduate student on the Council?

Jones: Reminded the Council that we have a fine, strong youth program. We can build from these programs.

President-Elect's Report: West was unable to attend (he will be here tomorrow). His report was read by Squiers.

Comments by Committee Chairs present: Postponed until Council meeting.

Academy Foundation Report: Guthrie submitted a written report. In his verbal comments, he cautioned the IAS to be careful with spending until we know what the economy is doing. He was also very pleased with Merrill-Lynch as the financial consultant.

Research Grant Report: Postponed until the Council meeting.

Action Items:

Proceedings: Make the *Proceedings* a semi-annual publication. The Publications Committee submitted the recommendation, and it was approved unanimously.

Web-site consolidation: Squiers is in charge of an *ad-hoc* committee to address this issue.

Mileage rate change: Mileage rate for McKnight (Publications) raised to $0.30/mile. Motion by Howes, Guthrie seconded, approved unanimously.

Award recommendations: Howes had none. Squiers presented the IAS resolution thanking the host institution, approved.

Change in format of Executive Committee meeting: Postponed.

Other: None.

Additional old business: None.

New business: None.

Meeting adjourned at 2:32 PM.

Respectfully submitted
Nils I. Johansen, P.E.
Secretary

COUNCIL MEETING

Indiana University-Purdue University Fort Wayne
8 November 2001

President Ed Squiers called the meeting to order at 3:07 PM. Attending: Executive Committee and Council members: Treasurer Ed Frazier, Secretary Nils I. Johansen, Past-President Ruth Howes, George Mourad, Jim Berry, Frank A. Guthrie, Bob Waltz, Executive Director Nelson Shaffer; Council members: Duvall A. Jones, Richard Kjonaas, Dan Webster, Donald Ruch, David Daniell, Bill McKnight, Holly Oster, William R. Gommel, Tracy Branam, Dick Conklin.

Agenda approved by consensus.

Minutes from meeting 20 April 2001 at Indiana University-Purdue University Fort Wayne, approved by consensus.

Treasurer's Report: Frazier submitted written reports.

In his oral comments, Frazier summarized by stating that the IAS is in good shape financially.

Academy Foundation Report: Guthrie distributed a written report. He noted that the value of the portfolio is down about 8% and the income is down about 1%. (The Foundation was commended by many for its efforts to minimize losses in view of the current financial situation.) The Foundation was also pleased with Merrill-Lynch as the fund manager. Guthrie cautioned the IAS to be cautious financially for the next year in light of the current (national) financial outlook.

Secretary's Report: Minutes of previous meeting distributed at the beginning of the meeting.

Executive Director's Report: Nelson distributed a summary of the status of the membership. In his comments he encouraged each member to get new members. If there are errors in the Yearbook, see him. If anyone would like to use the IAS travelling display panel, contact Nelson.

Newsletter Editor's Report: Squiers read Hansen's report. The deadline shifts proposed by Hansen were noted.

Proceedings Editor's Report: Berry showed an example of the new *Proceedings* lay-out. The *Proceedings* will now be a semi-annual publication.

President's Report: Squiers gave an oral report. We (IAS) are currently working along the lines of the 5-year plan devised at the retreat in the Spring two years ago. Issues addressed: (1) We need to continue to work on the public face of IAS. (2) We need to work on attracting professionals/researchers to the organization. (3) We also need to work on attracting graduate students and their professors, reminding them that the *Proceedings* is a vehicle of publishing. The new format with the greatly reduced turn-around time should make this attractive. (4) We need to continue to support Junior Academy functions. Few schools and few students are involved, but the there are *some really good ones* out there. In general, the Youth Activities program is good investment for IAS. Jones was thanked for his efforts.

The president listed a few frustrations: The wildflower bill has not passed, and we need to find younger members willing to take up the work in leadership positions.

And a couple of bright spots: The budget, the work with the Academy Foundation, the revisions of the *Proceedings*, the new publications (see Publications Committee report), and the research grant awards and the work of the research grant committee.

President-Elect's Report: The written report was read by the President. West stated in his written report that one of his goals for next year would be to carry forward the strong efforts of his recent predecessors as President.

Indiana Natural Resources Commission Representative's Report: Schmelz's report was distributed. There were no comments.

AAAS Representative's Report: Kjonaas gave an oral summary of activities since the spring meeting. The AAAS awarded IAS $1500 in support of high school research projects

Historian's Report: Gommel summarized four events this last year. (1) The AAAS award (see report). (2) The Junior Academy and Talent Search adjusted to a change in format and held exciting meetings this Fall. (3) The Research Grant Committee (see report) awarded 41 grants for a total of $51,700. (4) The Biodiversity and Natural Areas Committee and its subsection, the Indiana Biological Survey, have been active in establishing a computer data base for preserving State Collections.

The following members passed away last year: John M. Ferris, Leland S. McClung, Cornelius W. Pettinga (IAS President in 1991), Robert E. Wise. (These past members will be remembered with a moment of silence at the General Business meeting.)

Gommel also reminded the membership to forward resumes or biographical sketches to him, Howes suggested that members informed him directly or via the Executive Director or the Secretary of members receiving awards. Gommel agreed and said that this also would be an item for the Newsletter.

Committee Updates:

a. Publications—McKnight passed out copies of the two latest books: *Amphibians and Reptiles of Indiana* and *Dragonflies of Indiana*. He also submitted a written report on the activities of the committee.

b. Future meetings—2002: Daniell announced that the Spring and Fall meetings for 2002 will be at Butler University. The dates will be: 12–13 April 2002 for the Spring Meeting, and 10–11 October for the Fall Meeting. Because of this early date for the Fall meeting, the word needs to come out early. The Executive Director will include a note with the dues renewal. Information will also be in the Newsletter.

2003: Meeting at Anderson University;

2004: Potential site is Hanover College.

c. Research Grants—Mourad passed out a written report. Total for 2001: 51 Senior Grants for a total of $51,000; Spring Junior Grants—6 awarded for $1,100. The Fall Junior grants are still under review. Mourad then presented some comments. Persons who submit proposals need to pay attention to the paperwork. He thanked his committee members for a job well done. Howes thanked him specially, since she appointed him to the task when she was President. The Council gave Mourad and his committee a round of applause.

d. Biodiversity and Natural Areas—Ruch announced the Biodiversity workshop and the Special Session on the 9th. The special session is at noon, and the workshop is from 2–4 in the afternoon. One of the Indiana Biological Survey's goals is to have an "occasional paper" series.

e. Youth Activities—Jones passed out copies of the AAAS proposal and gave an oral report of the activities. Squires said that we (IAS) owe the Youth Activity Committee a great deal of thanks for its work.

f. Library Committee—Oster gave written and oral reports. Due to remodeling at the State Library, right now the files of the Academy are pretty much inaccessible; but the job should be completed soon.

g. Nominations Committee—Conklin gave the election results: 206 ballots were returned. Robert Waltz, President-Elect for 2002 and President in 2003; Stanley Burden, Academy Foundation; Jeffrey Hughes, Research Grants.

h. Awards Committee—Howes reported. No nominees.

Action Items: The action items from the Executive Committee meeting were forwarded and unanimously accepted.

Other old business: None.

New business: None.

Meeting adjourned at 5:11 PM.

Respectfully submitted:
Nils I. Johansen, P.E.
Secretary

Indiana Academy of Science

2001 Year End Financial Report

	Balance 1-Jan-01	Revenues	Expenses	Balance 31-Dec-01
OPERATING FUND	6,118.61			6,080.46
Dues		21,811.69		
Interest		300.09		
Contributions		325.00		
Spring Meeting		715.00	617.18	
Annual Meeting		7,375.00	5,676.95	
Transfer from IAS Foundation		6,000.00		
Officer's Expenses			4,000.00	
Operating Expenses			6,337.06	
Financial Expenses			1,033.38	
Newsletter Expenses			2,708.03	
Library Operations			3,027.09	
Committee Expenses			21.19	
Speaker of the Year			700.00	
AAAS Representative			881.80	
Web Site Development			1,000.00	
Youth Activities			10,562.25	
Operating Fund Total	6,118.61	36,526.78	36,564.93	6,080.46
RESTRICTED FUNDS				
Proceedings	36,653.08	20,384.00	18,207.00	38,830.08
Publications	(5,355.59)	120,072.23	115,520.70	(804.06)
* Research Grants	9,105.25	60,799.08	61,200.00	8,704.33
Indiana Biological Survey	0.00	5,000.00	5,000.00	0.00
Lilly Library	6,578.44	0.00	0.00	6,578.44
Welch Fund	10,037.52	368.49	500.00	9,906.01
Life Members Fund	4,016.94	200.00	421.69	3,795.25
Past Presidents Fund	8,741.39	407.00	0.00	9,148.39
Total Restricted Funds	69,777.03	207,230.80	200,849.39	76,158.44
TOTAL FUNDS	**75,895.64**	**243,757.58**	**237,414.32**	**82,238.90**
FUNDS ON DEPOSIT				
Checking Account	8,555.35	288,656.64	282,940.13	14,271.86
Money Market Savings	57,587.06	57,258.26	57,000.00	57,845.32
Cert. of Deposit	9,753.23	368.49	0.00	10,121.72
TOTAL FUNDS DEPOSITED	**75,895.64**	**346,283.39**	**339,940.13**	**82,238.90**

* Provided 41 senior member grants, 29 high school grants and 1 high school teacher fellowship

ACADEMY FOUNDATION FUNDS	
John S. Wright Fund Account	6,246,539.00
Academy Fund Account	177,723.00
Invested Income Account	209,231.00
TOTAL FOUNDATION FUNDS	**6,633,493.00**

Edward L. Frazier
Treasurer

INSTRUCTIONS TO AUTHORS

(*revised October 2001*)

General information.—Manuscripts and all correspondence should be sent to the Editor. To be eligible for publication in the *Proceedings*, at least one author must be a member of the Academy. Papers that have been presented at an Academy meeting may be given preference for publication. Submission of a manuscript to the Editor implies that it has not been sent to another publication, nor has it been published elsewhere. If it is accepted for publication in the *Proceedings*, it may not be republished without the written consent of the Academy.

All manuscripts are evaluated by referees. Submit three copies of the manuscript. Figures in manuscripts for review may be submitted as photocopies, and they should be approximately the size that they will be printed in the *Proceedings*.

After the manuscript has been accepted, the author will be asked to submit the manuscript as a paper copy and on a computer disc in a widely-used word processing program. Indicate clearly on the computer disc the **word processing program** and the **type of computer** (Mac or PC).

Galley proofs will be sent to the primary author for approval and correction.

Style.—Do not use right or full justification. Also, use a non-proportional font (e.g, Courier, but not Times Roman).

Title page.—The title page should include (1) the title in capital letters, (2) each author's name and address, (3) the running head (see below), and (4) the complete name, address, and telephone number of the author with whom proofs and correspondence should be exchanged, a FAX number and electronic mail address if available.

Abstract.—All manuscripts have an abstract, which should summarize the significant facts in the manuscript. The "ABSTRACT" heading in capital letters should be placed at the beginning of the first paragraph set off by a period. Use complete sentences, and limit the abstract to one paragraph and 250 words.

Keywords.—Give 3–5 appropriate keywords following the abstract.

Text.—Double-space text, tables, legends, etc. throughout. Three categories of headings are used. The first category (METHODS, RESULTS, etc.) is typed in capitals, centered, and on a separate line. The second (lower) category of heading, in bold type, begins a paragraph with an indent and is separated from the text by a period and a dash.(This paragraph begins with an example of this heading.) The third heading category may or may not begin a paragraph, is italicized and followed by a colon. (The paragraph below is an example.) Use only the metric system unless quoting text or referencing collection data.

Citation of references in the text: Cite only papers already published or in press. Include within parentheses the surname of the author followed by the date of publication. A comma separates multiple citations by the same author(s) and a semicolon separates citations by different authors, e.g., (Smith 1990), (Jones 1988; Smith 1993), (Smith 1986, 1987; Smith & Jones 1989; Jones et al. 1990).

Literature cited section.—Use the following style, and include the full unabbreviated journal title. Repeat the name for multiple references by the same author. Note that book titles have the first letter of each word capitalized.

Walter, J. & B. Hallet. 1979. Geometry of former subglacial water channels and cavities. Journal of Glaciology 23:335–346.

Walter, J. 1992. The significance and complexity of communication in moths. Pp. 25–66, *In* Insect Communications: Mechanisms and Ecological Significance. (P.N. Work & J.S. Rivers, eds.). Princeton University Press, Princeton, New Jersey.

Footnotes.—Footnotes are permitted only on the first printed page to indicate current address or other information concerning the author. These are placed together on a separate page at the end of the manuscript. Tables and figures may not have footnotes.

Running head.—The author's surname(s) and an abbreviated title should be typed all in capital letters and must not exceed 60 characters and spaces. The running head should be placed near the top of the title page.

Tables.—These should be typed double-spaced, one table to a page and numbered consecutively. Most tables contain only three horizontal lines (see recent issues for examples). Do not use vertical lines or shading. Include all pertinent information in the table legend (no footnotes).

Illustrations.—All art work must be camera-ready (mounted and labeled) for reproduction. Figures should be arranged so that they fit (vertically and horizontally) the printed journal page, either one column or two columns, with a minimum of wasted space. When reductions are to be made by the printer, pay particular attention to width of lines and size of lettering in line drawings. Multiple photos assembled into a single plate should be mounted with only a minimum of space separating them. In the case of multiple illustrations mounted together, each illustration must be numbered Fig. 1, Fig. 2, etc.) rather than given letter (A,B, etc.) designations. The name(s) of author(s), and an indication of top edge, and whether the illustration should be one or two columns wide, should be written on the back of the illustration. The overall dimensions should be no more than 11 inches (28 cm) × 14 inches (36 cm). Larger drawings present greater difficulty in shipping and greater risk of damage for which the *Proceedings* assumes no responsibility. In manuscripts for review, photocopies are acceptable, and should be reduced to the exact measurements that the author prefers in the final publication. Make notations in the text margins to indicate the preferred position of illustrations in the printed text. Color plates can be printed; but the author must assume the full cost, currently about $600 per color plate.

Legends for illustrations should be placed together on the same page(s) and separate from the illustrations. Each plate must have only one legend, as indicated below:

Figures 1–4.—Right chelicerae of species of *Centruroides* from Timbuktu. 1. Dorsal view; 2. Prolateral view of moveable finger; 3. *Centruroides* holotype male; 4. *Centruroides* male. Scale = 1.0 mm.

Page charges and reprints.—Page charges are currently $10 per journal page for members of the Academy and $70 per page for non-members. Corrections in proof pages must be restricted to printer's errors only; all other alterations will be charged to the author (currently $3 per line).

Reprints are available only from the Allen Press and should be ordered (with payment) when the author receives the proof pages. Allen Press will not accept reprint orders after the paper is published.

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